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ABSTRACT

The Elementary and Secondary Education Cost-Effectiveness Model originally developed to a detailed mathematical specification has now been developed into a computer programmed form which can be used at the school system level. This, the Office of Education Cost-Effectiveness (OECE) Model, is based on the major hypotheses that changes in student impedance (or resistance to learning) are proportional to changes in the quality and quantity of personal services provided by the school, and that changes in student achievement are directly proportional to changes in the quality and quantity of instruction and inversely proportional to total change in impedance. Students are considered in terms of those variables most easily ascertained by the schools. The model is outlined and the methodology by which its parameters are set and the steps by which it is used are described. Analysis of sample model runs is presented. Included in the appendices are directions for using and changing the model, description of the program organization, flow charts, and the program itself. (PR)

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TESTING AND FURTHER DEVELOPMENT OF AN OPERATIONAL MODEL FOR THE EVALUATION OF ALTERNATIVE TITLE I (ESEA) PROJECTS

For the
U. S. Office of Education
(Contract OEC-0-8-001681-1882(099))

by

Abt Associates, Inc.
Cambridge, Massachusetts

TM 000 119

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CHAPTER I

INTRODUCTION

This report describes work carried out by Abt Associates, Inc. for the U. S. Office of Education during the contract period of February 1, 1968 to September 1, 1968, and an extension period through November, 1968. (Contract No. AA-315, Testing and Further Development of An Operational Model for the Evaluation of Alternative Title I Projects, Phase I of two phases.) The purpose of the work was to develop the Elementary and Secondary Education Cost-Effectiveness Model into a usable computer-programmed form. At the beginning of this contract, the model, developed by Abt Associates in fiscal year 1967, consisted of a detailed mathematical specification. It is now programmed in a time-sharing computer language. It has complete and detailed user forms, and its parameters have been set. Test runs have been made with the model; the results seem reasonable, and provide good approximate figures. These tests are, however, no substitute for a large-scale and carefully controlled testing program, which would require a much greater effort than was stipulated in the contract.

The model in its present form may now be used for by individual school districts and/or researchers. This model cannot be said to be the ultimate in education cost-effectiveness models for the state of educational data and research is far too primitive to make such a statement valid. The model provides, however, a good example of the present state of the art, includes several innovative features, and is an excellent basis for future developments. The model considers students in terms of those variables such as achievement, dropout and truancy rates, and general attitude, which are most easily ascertained by schools. At the same time, it allows considerable room for development and change as future educational research may dictate.

This report outlines the model, discusses the methodology by which its parameters are set, and describes the steps by which it is used. Future users of the model will have the opportunity to set as

many parameters as they desire. Two major groups of parameters are involved in making a complete setting: those that describe student achievement change based on compensatory programs and those that extrapolate student achievement into the future by means of a Markov transition. Determining on-the-spot values for either set of parameters requires, ideally, a thorough study of student records in the district or school of interest. Methods of parameter setting which require considerably less effort are discussed later in the report.

The model is not meant to be a decision-making model, but rather a predictive one. It is believed, however, that it can be extremely useful as an aid to decision-makers and researchers. Models and human decision-makers complement each other. Models can carry out consistent detailed calculations very quickly and with great complexity of logic; men can apply years of experience to the results and judge the validity of the assumptions and hypotheses on which the output results and internal equations are based. The problem at hand can be understood in unprecedented scope and depth, and on this basis make better decisions.

> .... (the use of computerized models) does not imply automatic management. A better understanding of decision-making policy and its information-feedback context will not reduce the leadership demands on the executive. Quite the reverse. He will now have new methods to use and a new theoretical underlying structure to understand. The use of this new knowledge and these new tools will not be automatic. The more skillfully these tools are selected and the more significant the goals, the more effective will be the application.*

* P. 66, Jay W. Forrester, "Managerial Decision Making" in Computers and the World of the Future, Martin Greenberger, ed., The M. I. T. Press, Cambridge, Mass., 1962.

CHAPTER II

SUMMARY AND RECOMMENDATIONS

Development of the OECE Model into a working computer model which can be used at the school system level has helped to elucidate a number of characteristics of the educational modeling state-of-the-art and the interface between modeling and other activities in the field of education. Although these findings are detailed in subsequent chapters, their interdependence will perhaps be made more apparent by a brief discussion here.

The most basic task of systems modeling is common to all formal intellectual endeavors: that of determining concepts which somehow reflect real events and processes and then determining the relationships between the chosen concepts. Such a task is difficult in any science but is particularly so in the social sciences, which lack the uniparadigm integration of the harder sciences. The multi-paradigm nature of the social sciences is a result of difficulties in devising crucial tests. This problem stems both from the difficulty of developing indices to measure concepts, and the barriers to gathering accurate data for the indices.

Chapter III discusses in some detail the problem of determining concepts and their interrelations for an educational model. The theory of the OECE Model is described as based on two major hypotheses: (1) that changes in student impedance or resistance to learning are proportional to changes in the quality and quantity of personal services provided by the school, and (2) that changes in student achievement are directly proportional to changes in the quantity and quality of instruction, and inversely proportional to the total change in impedance. At this point, these hypotheses have not been disproven and therefore constitute an adequate basis for educational theory delineation. At the same time, as was noted in the previous paragraph, it would be surprising if no alternative educational theories contradicted these hypotheses. In the final analysis, adequacy of alternative theories must be evaluated according to the scientific criteria of explanation

(which theory provides greatest insight into the educational process), prediction, and control.

Such evaluation requires that the concepts be measured. This task (as is noted in Chapter III) includes the inevitable problem of lack of correspondence between that which should be measured and that which can be measured. In order that the model become operational it was often necessary to develop proxy measurable variables which were assumed to reflect other, unmeasurable variables.

Given the concepts and hypotheses relating them and given the indices which come closest to measuring the concepts, Chapter IV discusses the methods by which strengths of relationships between variables were determined. It is noted in that chapter that a lack of systematic, nationwide research into the causes of changes in student achievement poses difficulties for the task of properly estimating the model's parameters. Moreover, it is noted that since any social system is dynamic, changes in parameters are likely to occur over time. Thus, in social science, theory must constantly be subject to revision as both the insight gained from theory and changes in exogenous factors affect the parameters and algorithms of relationships.

Completion of model programming and setting of parameters permits actual use of the model. Chapter V discusses the model's usability in terms of correct functioning, feasibility of input requirements, interpretability of output and validity of output. The greatest problem was found to be that model results are extremely sensitive to the parameter settings. With proper settings, the model results seemed both interpretable and valid, although a much larger scale testing program would be necessary to adequately determine validity.

The experience gained from development of the Office of Education Cost-Effectiveness Model into a form of high usability permits a number of conclusions about the process of educational modeling and the relationship of educational modeling efforts to other research activities in education.

1) It is possible to model the educational process using measurements which are readily available to the user. Such a model can be used to make predictions about the relative effectiveness of different allocations of both financial and human resources.

2) Modeling capabilities present no constraints on the validity of predictions made by a model. To the extent that accurate information about relationships is known, such information will permit valid prediction.

3) Information constraints on modeling efforts stem from inadequacies in three interrelated components of educational research: specification of theory, development of measurements, and basic research. A model can only be as valid as the theory on which it is based. Even if the theory has merit, it is necessary to have measurements which are both meaningful and usable. Finally, systematic and high quality basic research on both static relationships and the dynamics of changes in relationships is essential to valid modeling.

4) Since the present OECE Model is more refined and differentiated than the available information used to set its parameters, it will be possible to revise the model as better information becomes available without substantially altering the model's framework.

5) Since educational modeling focuses attention on the entire range of research activities from specification of concepts and theory to development of measurements and research into relationships, and since the output of model use is predictions, the model is a convenient tool for stimulating educational research on all fronts, especially if systematic method and incentives are developed for model use and reporting of results of model use.

Recommendations

1. The OE Cost-Effectiveness Model has been designed primarily for use as an aid to improved decision-making and resource allocation at either the school system or school level. It is not known at present what the impact of widespread model use would be, since the OECE Model is presently unique in its capabilities for application in a variety of educational situations. It is quite conceivable that use of the model, or a more refined version, would significantly improve educational outputs either through its accuracy or merely by familiarization of users with education systems concepts. In addition, model use and reporting of results would indicate strong and weak points of the model, both conceptual and empirical, and situations in which model results have high and low validity. Widespread use of the model, in short, would not only provide benefits to school systems, but also provide a basis for evaluating overall utility of the model and ways in which it can be improved.

It is, therefore, recommended that the Office of Education,

A) Make the OECE Model available for general use, publicize availability among potential users, and provide incentives for model use. Incentives could take a number of forms, but the most effective would probably take the form of grants which cover some or all of the costs of model use.

B) Develop a systematic method for reporting, storage, and retrieval of the results of model use. To this end, incentives for use should be contingent on formal reporting of results. Storage and retrieval could probably most efficiently be accomplished by use of the ERIC system, in which reports could be listed under a special category.

2. The present report emphasizes the fact that validity of model results depends substantially on accuracy of the numerous parameter weightings. Such weightings cannot be considered invariant: importance of many factors in the educational process differs most notably by region and ethnic composition, as well as over time.

In order that the maximum validity and, therefore, utility of OECE Model application be achieved, it is recommended that the Office of Education provide resources for the development

of a parameter handbook which would list parameter settings for all significantly different situations. Such a task, though formidable, would substantially increase the utility of model use, and, in addition, provide a great deal of basic research information which could be used for other purposes.

3. As is discussed in several sections of this report (e.g. Chapters IV and V and elsewhere), the present lack of comprehensive research on causes of student performance and changes in performance is a far more limiting constraint on successful modeling of the educational process than is the state-of-the-art of modeling per se. Any model, regardless of its conceptual sophistication and ability to integrate diverse types of information, is severely limited in its validity by the degree of accuracy concerning strengths of relationships and the validity of data upon which the model operates. The first and second recommendations of this report deal in part with ways of alleviating the present deficiencies of educational research, but neither fully deals with the questions of which factors are most significantly associated with student performance, because neither explores beyond the relationships already contained in the OECE Model.

It is recommended that detailed basic research of a comprehensive nature be undertaken in a small sample of cooperating school districts to alleviate this gap. The research should be comprehensive in the sense that for a given school district, it would explore all conceivable dynamics of the educational process which have a direct or indirect effect on student performance. It should be basic in the sense that it would concentrate on isolating empirical relationships, rather than on determining the strength of relationships which have already been structured in a theoretical model. While efforts described under the first and second recommendations would provide the basis for more finely tuning the present model, comprehensive basic research would provide a means for structurally modifying the present model, or if that proved unfeasible, developing a second generation model to move accurately simulate the educational process. Whereas

the first and second recommendations have concerned a broader scope of research, this recommendation is concerned with greater depth.

4. It has not been assumed that the values to which the parameters of the model are presently set are fixed in any sense. Chapter IV discusses the problems of the currently incomplete knowledge of the relationships involved in the educational process, and the problems of the changing nature of these relationships over time. The model should not be static. Its parameters should be adjustable to the situation of changing knowledge.

At present, the only way to change or update the parameters is to erase an old value and type in a new one. This method is acceptable for cases in which the new value completely supercedes the old one. However, there are many instances in which new knowledge about parameters does not negate the previous values, but is simply more data which has to be added to the existing data, the sum of the knowledge being used to compute the parameter settings. An example of parameters for which this is likely to happen is the set of Markov matrix transition probabilities. There are well known methods of updating parameters by weighting old and new knowledge to form the best estimates of the new values. The problem is a classical one of Bayesian statistics. It is, therefore, recommended that the model be designed to more or less automatically update its parameters by use of Bayesian statistics.

5. The model is at an early stage in its development, and needs both more and more thorough tests to insure reliable operation. It is presently designed to be operated by a specialist or trained layman--someone who is both somewhat familiar with the mathematics and with the computer program design. Administrators who want answers to their planning questions must transmit raw data to such a specialist to be decoded and placed in the computer. This step not only removes the model's operation from the administrator, but also make the process somewhat cumbersome. Ideally, the administrator should be able to

sit at a time-sharing computer console and try the alternative strategies himself; most adminis-trators lack the training to be able to do this.

The ideal mode, of course, involves interfacing with the computer persons who are not likely to have a working knowledge of computers. Conversations with the computer will have to be in a language which the user understands and with which he is familiar. There are many of these types of languages in existence today. Special programs such as SNOBOL have been created to facilitate, among other things, generation of interactive computer languages. Using this and similar programs, a language which is very close to English and employing the terminology familiar to administrators could be developed. This would bring the process home to the administrator and give him complete control over the computation without his having to develop specialized computer facilities.

6. During the development of the model, the Markov transitions proved to be a workable but somewhat limited method of describing the student flow from grade to grade. This method of describing transitions is inherently a discrete process. Changing achievement levels, a continuous measure of performance, had to be broken into states of achieving above and below threshold achievement rates. Describing the process by percentages above and below the threshold introduces an approximations.

It would be more desirable to have a matched method of predicting achievement changes and of projecting student performance. Since the continuous process is the more accurate, it would seem reasonable to make the projective method also continuous. One of the ways of accomplishing this is to investigate the use of time series analysis--a continuous process-- for projecting student performances. This essentially implies that a student's performance in any given grade is a linear function of his performance in previous grades. This would eliminate the discrete treatment and hopefully increase the overall accuracy of the model.

7. It is well known that the learning which takes place in a school setting is very strongly influenced by the background and extra-school environment of the student. Attempts have been made to consider these influences through the inclusion of factors of student background in the model. The relationship between the in-school process and the out-of-school process is considerably more complex than its present treatment in the model. This relationship can only be crudely represented at present due to the lack of existing research into the variables and processes involved.

It is recommended that research be carried out to investigate this relationship. A useful first step might well be the modelling of the process from available research and data, to be followed by the investigation and testing of the postulated interations. This sort of goal-oriented research should have greater immediate pay-off than less structured research. A useful testbed for the modelling of the community-school interaction would be the present OECE Model. It is expected that the community submodel could be enlarged and feedback mechanisms developed to integrate the new knowledge into the present model.

CHAPTER III

THE MODEL

III. 1 THE OVERVIEW

The OECE Model has been developed to serve two major purposes. It enables administrators to compare in depth proposed compensatory education programs, and also to examine the long-range results of both proposed and existing programs. Examination of the strategic effects of school programs, a major task of administrators, requires detailed information on the long-term practical effects of education. The fact that special reading instructors improve reading achievement is difficult to interpret without information on the eventual results, in terms of future academic performance and usefulness the community, of the improvement in reading ability. The model's theoretical basis is the premise that these long-term effects and specific educational inputs can, in quantitative terms be correlated. This requires the input of quantified variables, describing in detail the student population and schooling levels before and after compensatory education.

For purposes of comparison, a "base-line" run is made. This uses the schooling levels before compensatory education to establish within the data banks the various levels of initial school inputs and to project probable student performance after compensatory education. Comparison of these results with the baseline outputs permits evaluation of the probable efficacy of the program.

The development of the model for evaluation of proposed Title I Projects requires a thorough understanding of how and to what extent the various aspects of the overall student environment affect student attitudes and achievement. Complete understanding is not possible, nor are the causes and effects related by strict rules, so it is never possible to predict precisely what will happen to a group of students when certain changes are made in their school environment. On the other hand, it is possible to gain use-

ful information by isolating those aspects of the environment that appear to have the greatest influence on student performance. By applying the findings of educational theory and experimentation, the isolated variables can be related to one another in such a way as to simulate the educative process.

The Office of Education Cost-Effectivenes (OECE) Model is a first attempt at simulating the actual process of education in a general framework. It was designed to permit evaluation of the relative effectiveness of alternative Title I Project proposals for compensatory education. Its principal function is to provide a more systematic and unbiased assessment procedure than either educated guesswork or historical comparison now provide.

A model of any incompletely understood process is necessarily in part a simplification and a distortion. It cannot be exhaustive or highly accurate, as it does not take into account every factor in the process, and because the relationships even between included factors are not precisely understood. The OECE Model is no exception to this rule. Its designers were faced with the problem of determining which of the known elements of compensatory education were of primary interest before they could represent the process symbolically. The choices were affected by consideration of the ultimate purpose of the model and by the availability of supportive theory and required data.

Underlying the model are important hypotheses derived from qualitative learning theory, some quantitative research results of Davy, Bloom, and Coleman and assumptions made by the design staff at Abt Associates, Inc., and by their consultants.

Instruction is the principal sub-process of education. The teacher, the curriculum materials, and the classroom itself represent the potential amount of learning that can be gained by any student of satisfactory ability. If completely responsive to his environment, the student would absorb all that could be learned in the classroom to the level of his ability. In effect, his resistance to instruction would be nil and the knowledge transmitted to him would be assimilated completely. However, students may and often do resist instruction.

The difference between what is taught and what is learned (ability aside) is defined to be the resistance the student has to his educational environment. When a large number of children in an ordinary school are under-achievers, the achievement gap can probably be attributed almost entirely to resistance, rather than to limited student ability. Whatever his reason, whether laziness, fatigue, dislike of the teacher, boredom, anxiety, or even lack of nourishment and proper clothing, a student reduces the efficiency of teaching by his negative disposition.

If grading in a given classroom is perfectly fair, then teaching efficiency is measured by the difference between what is taught and what the student learns. This will be reflected in the level of student achievement. That is to say, student achievement can be described in terms of the amount of potential instruction increases, if the student's resistance either remains constant or decreases. It also suggests that if the amount of potential instruction were to remain constant and the resistance of the student were decreased, achievement would also rise. An analogy can be drawn between this simple relationship and Ohm's Law in electrical theory. Instruction flows from teachers to students, whose resistance lowers the resultant achievement force.

An interesting problem arises: how interdependent are instruction and student resistance? Can there be any achievement if resistance is abnormally high or instruction abnormally low? Common sense indicates that as long as resistance remains extremely high, improvement of instruction will not measurably increase student achievement. Nor will reduction in student resistance raise achievement levels, as long as instruction remains very poor. An experienced teacher of youngsters from culturally deprived homes will no doubt agree that little learning takes place when students start out negatively disposed toward schoolwork and receive no reinforcement outside the classroom. On the other hand, students from privileged backgrounds are intolerant of low-level teaching and may actually increase their resistance as the quality of instruction decreases.

These conceptual relationships among levels of instruction, resistance, and achievement can be translated into a model of compensatory education.

First of all, by its very definition, compensatory education is designed for students resistant to normal schooling. These students are underachieving because they are not learning all they are taught. Changes in the amount and type of instruction (within the proper range of resistance) will yield gains in student achievement. Changes in resistance will similarly increase achievement if the instructional level is adequate.

Changes in the amount of instruction can be brought about by compensatory projects aimed at improving the quality of teaching or the quality of the curriculum. Changes in resistance can take place as an indirect result of compensatory service projects. Service projects aim to reduce the ill-effects of improper health and welfare attention in the students' home environments. By so doing, such projects tend to increase students' receptivity to learning or, in terms of the model, reduce their resistance to formal instruction.

The next step in defining the model is to identify those aspects of instruction, service, and student resistance that contribute most heavily to determining actual achievement and attitude change. Davy, Bloom, Coleman, Bernstein, and other social psychologists have made significant advances in identifying the characteristics of a student's environment that account for a large part of his achievement change. Unfortunately, the variables they have suggested in their research are not usually objectively measurable with any ease. For example, a student's sense of mastery over his environment, his need-achievement, his parents' valuing of education, the norms of his peer group, the verbal facility of his teacher, and the language patterns of his parents are identified as crucial influences on student achievement. Attitudes toward school appear to be less determinate than achievement and dependent upon even more inaccessible variables.

Instead of using the theoretical influences identified in the literature of educational research, it was necessary to find reliable and accessible indicators that would indicate the most decisive aspects of the crucial variables. The parents' level of education, for example, was selected as a reliable indicator of the value placed by the parents on education. Other indices, such as the newness of curriculum materials as related

to their interest and relevance for the students appeared to be less reliable because of the limitations on the standardization and collection of objective data.

Numerous such indices, representing the significant influences of the home and school environments on student attitude and achievement change, were grouped into the four categories: achievement change, instruction, service, and student resistance to instruction. Each category received an overall index equal to a weighted linear combination of each of its variable components. Each weight represented the amount of influence attributed to a given variable within its particular category.

The first step in the design of any model is the definition of outputs to serve the model's objectives. The outputs of the process of compensatory education are defined here as changes in student attitude and achievement. Presumably, these changes will vary in accordance with the differential emphasis of various compensatory education projects and the amount of effort expended on them. For purposes of evaluation, however, the effects of the programs must be combined with their costs in order to arrive at a practical measure of their relative values. Two competing projects, for example, may yeild equivalent achievement gains for the target population, but at widely varied costs. The cheaper of the two projects would then be the more cost-effective. Two other projects may yield equivalent gains in incommensurate categories, such as reading and arithmetic, at the same cost. In this case, cost-effectiveness is identical for the two projects, unless one subject is considered more beneficial to the students than the other.

The second step in the design of a model is the selection of instrumental variables and data inputs. The instrumental variables in the compensatory education process are those influences on student attitude and achievement change which can be improved by projects under Title I. Since Title I projects are divided into categories of personal services and of instruction, these same categories have been used in classifying school environment variables.* Both categories are divided into measures of their quality and quantity; the combination of these two measures re-

presents the total impact of service and instruction on ultimate changes in student attitude and achievement.

Data inputs consist of a detailed description of the proposed compensatory education project and a characterization of the target population. The Title I Project is described in terms of its costs and its intended effects on the quantity and quality of services and instruction provided by the school. The components of Title I changes are described in terms similar to those of the instrumental variables, in order to eliminate the need for conversion.

Students are characterized in two complementary ways. The first classification is according to their ethnic background and family income. The model deals with four "student types": (1) whites who's parents' income exceeds $3,000; (2) non-whites who's parents' income exceeds $3,000; (3) whites whose parents' income is less than $3,000; and (4) non-whites who's parents' income is less than $3,000. This breakdown has been created so that possible differences in student background and the resulting impedance to learning may be rated. The categories are flexible; certain school districts might, for example, want to designate Spanish-American as an ethnic type, or to change the income threshhold level.

The second description is of student impedance (resistance); this represents the degree of scholastic disadvantage that characterizes each student type. It is a measure of home and school background factors presumed to retard learning in the target groups.

In a model, input variables and instrumental variables which interact with one another are combined with one another to produce the outputs. The combinations and interactions of the variables requires a set of decision rules and precise designations of mathematical relationships. These rules and relationships constitute the theory of the model.

The theory of the CECE Model is relatively simple. In consists of two basic hypotheses and a number of additional assumptions. The first hypothesis is that the decrease in student impedance is proportional to the total increase in the quality and quantity of personal services pro-

vided by the school. It is assumed that improved services in the school will tend to reduce the scholastic disadvantages acquired by the target students both in their homes and in previous years at school. The change in scholastic disadvantage forecast by the model is taken to be equivalent to the change in student attitude, and, as such, is output.

The second hypothesis is that the change in student achievement is directly proportional to the total change in the quantity and quality of instruction, and inversely proportional to the total change in impedance. This implies that achievement change can be accomplished either by holding impedance constant and increasing instruction, or by holding instruction constant and decreasing impedance.

Additional rules, however, govern the behavior of these relationships. Service components of compensatory education projects are matched against the particular disadvantages of the target population before any impedance change is computed. If the service improvements are not relevant to the student disadvantages, then no impedance change is recorded.

A second constraint on the behaviors of the variable relations is the imposition of threshholds. One example of the operation of this constraint occurs in the computation of impedance change. Because impedance change actually represents student attitudes, there is much evidence to suggest that there is a practical limit on the amount of change that could occur in a single year, regardless of the amount of service improvement in the school. Thus an upper limit has necessarily been placed on the impedance change relationship for any given year.

These two basic relationships can predict the immediate impact of a compensatory project on student attitude and achievement. Evaluators interested in the longer-range effects of a given project can turn to the following four features of the model: (1) the effect of a change in achievement in the year of impact on achievement in future years, projected to grade 12 (School Flow submodel); (2) the effect of changes in achievement and impedance in the year of impact on student absence (Truancy subroutine) and dropout frequency (Dropout subroutine) to grade 12; (3) the

predicted lifetime earnings of students (Community Effects submodel); and (4) the effect of changes in achievement in the year of impact on the equality of educational opportunity (Community Effects submodel).

The School Flow submodel has been developed with the basic assumption that early failures in academic subjects may lead to later failures in other subjects. This effect is likely to spread itself in later years of school, due to increasing reliance of new subjects on those previously taught. For instance, reading ability is vital for most subjects from early elementary school on, mathematical skills are necessary in a wide variety of subjects during the student's school career, and science and social studies courses often build on knowledge gained in previous courses. Detailed studies of achievement data collected by Abt Associates staff members both in the Greater Boston area and in Iowa revealed that patterns of spreading achievement failure do indeed exist both for achievement test data and for teacher-assigned grades.

The School Flow submodel projects the incremental effects of compensatory programs plus the effects of ordinary schooling for each year. This model is based on assumed subject interdependencies in the core curriculum, and computes changes in the probabilities of progress at an achievement rate which is either above or below the national, state or regional norm.

The subject-grade interdependencies are simulated in the model by the use of a one-stage Markov model; probabilities of a student's achieving at an above-average rate in one grade are determined by the achievement pattern of courses he passed in the previous grade. The number of truancies and dropouts is computed on the basis of the average achievement lag of the population. This entire process is repeated for each grade or grade group (e.g., 1-3, 4-6) until the population has completed the twelfth grade.

Dropout and truancy phenomena have been shown by research to be intimately connected with student achievement lags behind the national norm. A very simple linear relationship is found to model the empirical data quite successfully. Thus, in the context of the model, the only way to decrease dropout and truancy rates is to decrease the achievement lag.

This is not, strictly speaking, a legitimate conclusion to draw, but it seems to work in practice. In any case, the relationship should be the subject of further research.

The Potential Lifetime Earnings portion of the Community Effects submodel is based on census report data and on studies of the correlation between lifetime earnings and educational level achieved. As the grade at which the student leaves school increases, so do his achievement level at graduation and his probable lifetime earnings.

The Index of the Equality of Educational Opportunity is based on Coleman's concept of the relationship between school achievement and socio-economic background. It is described in detail in Chapter III. 6 .

Any given compensatory education project will have costs associated with its components of environmental change. When the effects are tabulated for these changes, the individual project effects and costs can be studied to determine the relative cost-effectiveness of the projects.

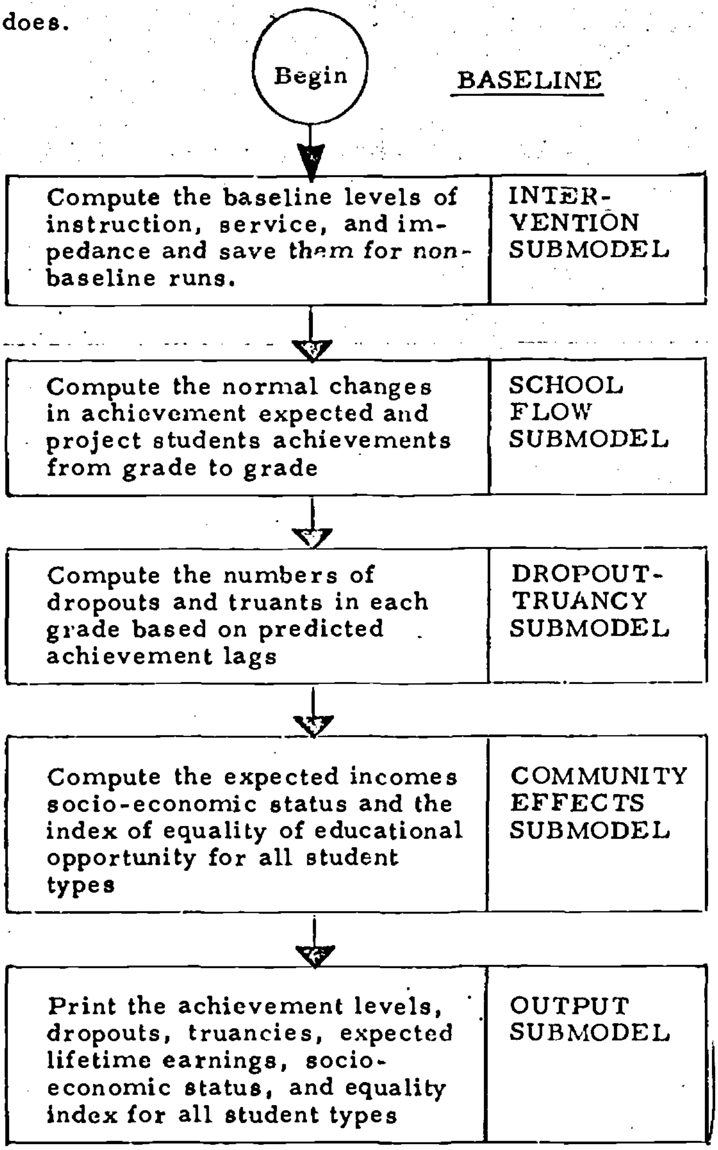
The OECE Model was developed for the purpose of assisting in the evaluation of alternative proposed Title I Programs in any particular school district. The model is of a limited scope, and it is important here to point out two important limitations. First, the development of the model was influenced by the fact that the model is required to deal with a wide variety of school districts throughout the United States. The records and data in these different districts vary widely in quality and philosophy. Unfortunately, it is necessary in such a situation to design a model which would accept as input data which are often insufficient or lacking in quality.

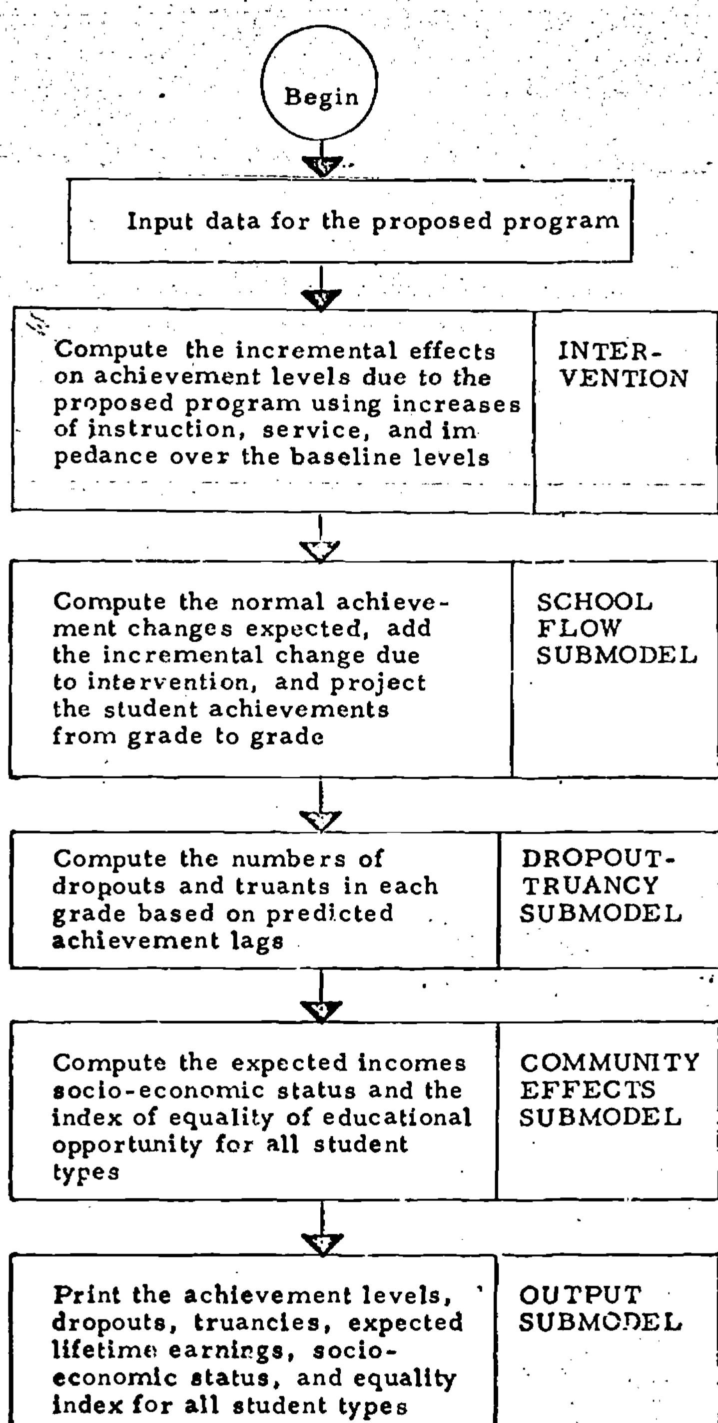
Second, the model can not allocate funds to specific communities, select the best combination of programs or prescribe exact expenditures. In the hands of a skilled user, however, it will help to determine the relative effects of alternative programs, and can therefore be a powerful tool for evaluation. To build a model capable of generating and optimizing programs for a group of school districts, a great deal of additional resources and effort would be required.

A Brief Profile of the OECE Model

Function	The Model Will:	The Model Will not:
Students and student change	Deal with groups of students Deal with students below national norms Indicate changes in student group achievement	Deal with individuals Evaluate programs to raise achievement of students above national norms
School change	Indicate changes in rate and year of dropouts Indicate increased or decreased numbers of high school graduates Indicate changes in course of study selection where applicable	Simulate changes in the administrative policy in a school district
Community change	Indicate changes in potential life-time earnings Indicate changes in equality of educational opportunity	Simulate change in the home as a result of Title I
Evaluation	Compare the cost-effectiveness of proposed Title I and other educational improvement projects within a school district Aid decision-makers Determine relative effectiveness of proposed Title I programs	Compare proposed Title I projects across districts Make decisions Determine absolute effectiveness of proposed Title I programs
Data input	Need commonly available data	Give results more precise than the input data

The following flow chart gives a simplified view of the structure of the model. It may be helpful in visualizing how the model works and what it does.




Begin
Input data for the proposed program
Compute the incremental effects on achievement levels due to the proposed program using increases of instruction, service, and impedance over the baseline levels
INTERVENTION
Compute the normal achievement changes expected, add the incremental change due to intervention, and project the student achievements from grade to grade
SCHOOL FLOW SUBMODEL
Compute the numbers of dropouts and truants in each grade based on predicted achievement lags
DROPOUT-TRUANCY SUBMODEL
Compute the expected incomes socio-economic status and the index of equality of educational opportunity for all student types
COMMUNITY EFFECTS SUBMODEL
Print the achievement levels, dropouts, truancies, expected lifetime earnings, socio-economic status, and equality index for all student types
OUTPUT SUBMODEL

III.2 THE SCHOOL FLOW AND INTERVENTION PROCESSES - INTRODUCTION

The School Flow and Intervention Submodels are at the core of the Cost-Effectiveness model. Their purpose is to compute the immediate effect of alternative compensatory education programs, and to project that effect into the future. These calculations are basic for the function of the subsequent submodels of dropout- truancy rates and community effects. Knowing all of these effects and their long-term consequences for student performance and behavior, the administrator can choose that program which, for a given cost, provides the maximum return.

The School Flow process represents the action of the status quo; operating alone, it simulates performance patterns when there is no intervention by compensatory programs (i.e., it represents the baseline situation). The Intervention Process, on the other hand, represents the incremental effects of compensatory programs. The two processes, while performing the same function of describing the school's effect on the student population, are of very different natures in terms of their inputs and results.

Before proceeding to a discussion of the two processes, it is important to define the term "effect" as it is used here, and to describe the ways in which it is measured. There are numerous methods of measuring student performance; each has its own advantages and disadvantages. Achievement test scores, achievement rates, course grades, and passing and failing frequencies are all generally associated with student advancement and learning processes. For a variety of reasons, which will be discussed below, achievement test scores and achievement rates (grade level equivalents per year) have been chosen as indicators of student performance.

In a hypothetical compensatory program consisting of a number of program components, the School Flow and Intervention Processes both causes each year an increment in the pre-existing achievement level of the student population. The two increments are simply added

together to yield the total increment, which represents a new achievement level. Thus, the grade equivalents of achievement levels in the various test categories advance from year to year for each type of program tested with the model.

The School Flow Submodel need not be explicit in terms of the relationships between the school and students. What is required instead is an implicit model, describing grade-to-grade transitions without explicitly stating the reasons for them.

For example, it is not necessary to say that a particular program caused a specific achievement change from fifth to eighth grade. It is sufficient to say that, on the average, a certain proportion of students attaining achievement level A in the fifth grade will attain achievement level B in the eighth grade. With these guidelines in mind, the Markov transition process is used to measure the students' ascending achievement rate. This is described in detail in Section III. 4.

The Intervention Process Submodel, on the other hand, describes the explicit relationship between the achievement of the student population and the variables that affect the achievement rate. Student achievement is affected positively by many of the variables that the school manipulates, and negatively by the students' environmental disadvantages. A school may have to feed a hungry child before he can be taught. Training teachers to be sensitive to the problems of disadvantaged youngsters contributes to more effective teaching and, ultimately benefits the entire community as well. The model must describe quantitatively the relationship between these controllable school inputs and student achievement and behavior. We have chosen three major factors that affect student performance: (1) the instruction given by the school; (2) the physical and counseling services supplied by the school; and (3) the student's resistance or impedance to learning. For each of these factors, we have chosen a linear model which uses the simplest mathematical functional relationships. Increasing the services supplied by the schools tends to decrease the child's resistance or impedance to learning. The

decreased resistance tends to result in increased achievement level. Increasing the quality of instruction in the schools tends also to increase achievement level. These three factors are combined in a very simple mathematical expression, analagous to Ohm's Law in electricity, to indicate student achievement rates.

This combination of school flow and intervention operates at every grade or grade group (a set of grades at the beginning and end of which achievement tests are given). It is assumed that the levels of instruction, service, and impedance remain constant for each set of grades; average levels are chosen.

III.3 THE INTERVENTION SUBMODEL

The Intervention Submodel is the most important element of the overall cost-effectiveness model. It computes the incremental effect on student achievement of compensatory programs. The output projections by the School Flow Submodel, the Dropout Submodel, and the Community Effects Submodel depend directly on the accuracy of the changes in achievement computed by the Intervention Submodel. Two or more compensatory projects, having different components of instruction and service, produce differing patterns of achievement changes. The submodel then forms the basis for all of the subsequent predictions and comparisons.

Two assumptions are implicit in the Intervention Submodel. The first is that under-achievement and the lack of motivation among students from low income homes is environmental rather than heredity. The second, following from the first, is that proper changes in the school environment, such as services from the school to offset disadvantages, and better instruction to stimulate achievement, can contribute significantly to reduction of learning difficulties and eventually improvement of student attitude and performance. A more ambitious future model would also have to consider the impact of home and community changes on student achievement; this is, however, beyond the scope of the present effort.

The Intervention Model manipulates two major variables:

1. The average rate of achievement in a subject: if the average pupil achieves normally in each subject, this rate is one grade level per year.

2. The average achievement level: this represents the total of the achievement rate over his years of schooling. If a pupil progresses normally in a subject, his achievement level in that subject will increase by one each year. If, on the other hand, he should progress at only half the normal rate, he would have only second-grade achievement in grade 4, third-grade achievement in grade 6, and so on. To catch up, he must progress at a faster-

than-normal rate (an achievement rate greater than 1). Compensatory education programs aim to give disadvantaged pupils the boost they need in order to overcome their achievement lag.

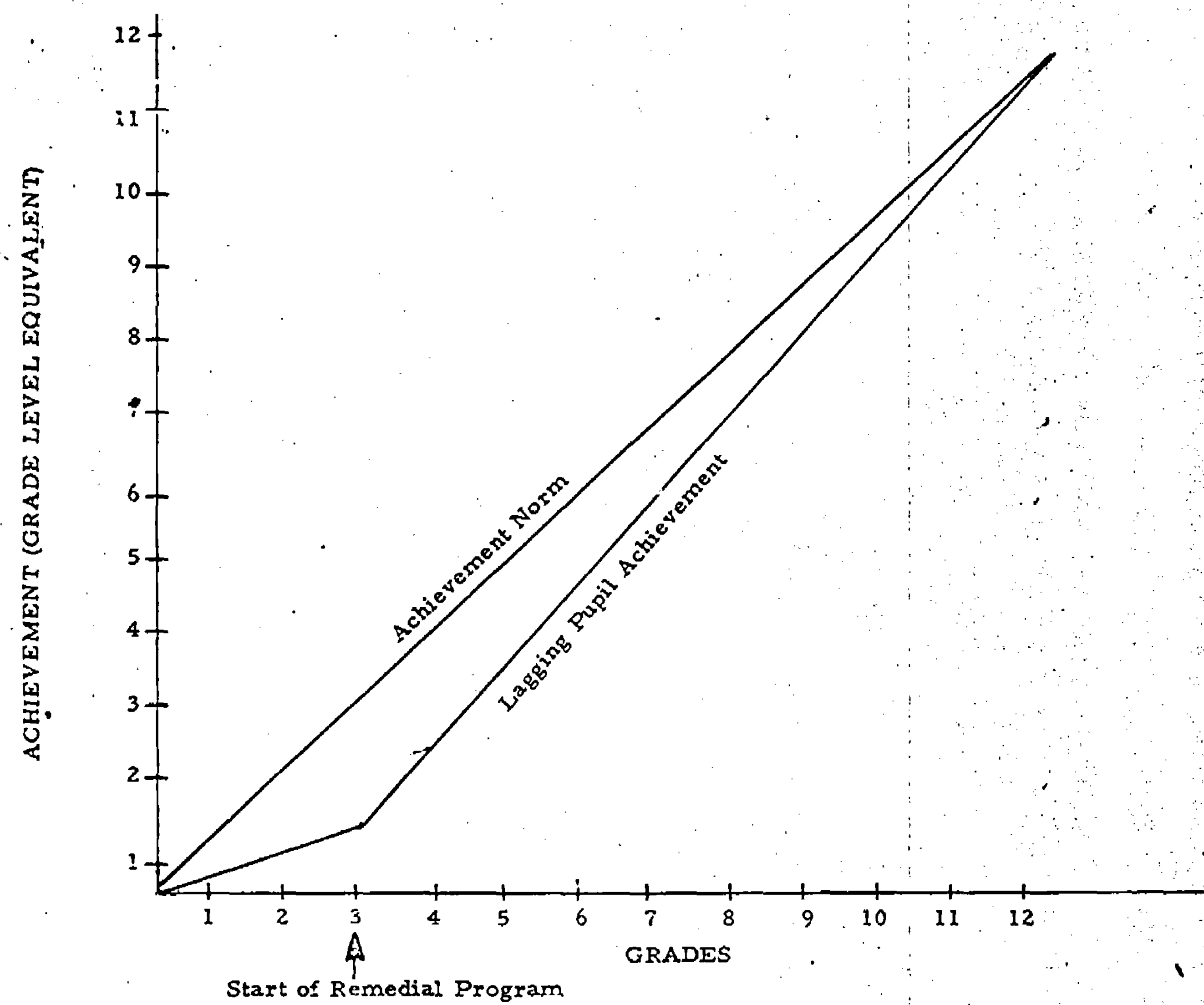
If the average educational achievement of a population of disadvantaged students at the end of each year is measured in terms of grade level norm, the achievement and time curve might be as shown in Figure III. 3. 1. In this hypothetical situation, the pupils' lag behind grade level increases for the first two years. However, at the start of the third year, a compensatory program is implemented, and its provisions are maintained in following years. This is, moreover, a highly effective program; it gradually brings the performance of the group up to the level of general norm.

Since these annual achievement measurements are the only information available about the progress of the disadvantaged population, we approximate the achievement curve of a series of straight line segments. The slope of each segment represents the average rate of achievement over a year of schooling.

In this model, rate of achievement can be manipulated indirectly. This corresponds closely to reality. If intense educational processes are introduced by compensatory programs, one cannot expect an instantaneous change in the achievement level of the students. One can expect, however, an acceleration of the learning rate. Ideally, a rate of achievement higher than that of the national population or the regional population is maintained until the disadvantaged population has the same distribution of achievement patterns as the normal population. The model is, in fact, constructed so that the achievements of the disadvantaged population cannot exceed that of the normal population.

The model regards achievement rate as the joint result of the instruction that pupils receive and of their resistance or impedance to that instruction. It assumes that pupils learn more rapidly under conditions of better instruction and less impedance. Services offered by the school to improve student well-being can reduce the impedance of the student. Therefore, service is another variable affecting achievement rate.

Figure III. 3. 1



This model represents the level of instruction as the sum of the effects of the quality, intensity, and duration of instruction. Instructional quality results from the training and experience of teachers and from the qualiyt of instructional material. Instructional intensity depends upon the number of teachers, texts, and desks available, and on the amount of money in the instructional budget. The duration of instruction is simply the amount of time pupils spend under instruction.

Before intervention, impedance is represented as the sum of the effects of six factors of disadvantage: (1) poverty; (2) low level of parental education; (3) physical handicaps; (4) family disruption; (5) depressed achievement level of a pupil's peers; and (6) the pupil's own depressed achievement level.

The model represents the level of service as the sum of the effects of the quality, intensity, and duration of service. The quality of service depends on the absence or presence of prior programs of the type being considered, and on the programs, cost, if any, to the students. The intensity of service is a function of the number of para-professionals employed, the space available, and the budget spent on service. The duration is the amount of time the students are exposed to the service.

It should be noted here that in both the model and the program, the variables listed above are completely flexible and subject to changes. The variables listed above were chosen for the ease with which they can be measured. It is necessary to ask whether the e variables are useful if their correlation with the variable which they are to affect is low. Softer, less easily measured variables whose correlation with the output variable is high would, in the hands of a practiced evaluator, result in a more responsive model. These variables would, however, be subject to biases, depending on the observer, and thus to gross differences of standards in their measurement. The use may employ the model in either way that he wishes, or in both. He may replace the existing variables by variables of his choice, or add more, or do both.

A large number of evaluations of compensatory education programs are now underway throughout the Nation. At the date of this writing (December, 1968), the variables that are critical in affecting student performance have not been pinpointed. Thus, the final product awaits the results of research which is still in progress. As these instrumental variables become clarified, they may, without difficulty, be added to the model.

Levels of instruction, service, and impedance are computed using both pre- and post-compensatory conditions. The quantities actually used to calculate the achievement change are the changes in instruction, service, and impedance from the baseline (i.e., pre-compensatory) level.

The flow chart in Figure III. 3. 2 describe the flow of information and the interactive influences of the quantities. The mathematics of the model may now be considered in detail.

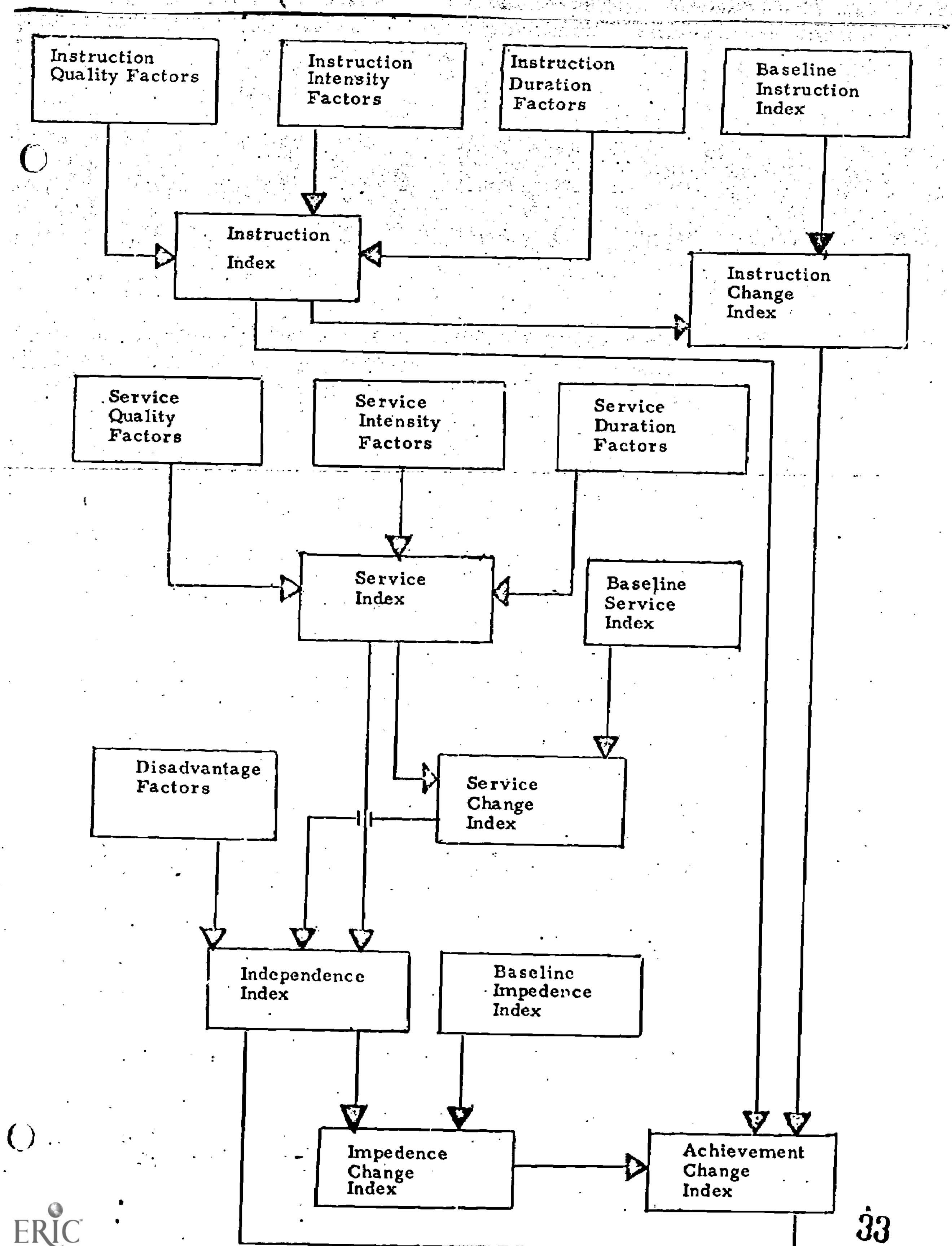


Figure III. 3. 2

INSTRUCTION

Instructional Quality

The quality of instruction is affected by two variables--one measuring the quality of the curriculum and the other the quality of the teacher. The two chosen here to represent the quantities are RECEN, and index of the recency of publication for textbooks used, and TCHEXP, an index of teacher experience. As with all of the other variables of this type, the user is free to interpret these in whatever manner he wishes. For example, he may use an index of teacher quality based on verbal ability, number of degrees, number of graduate credits, or any of a number of measures, or he may straight-forwardly use an index indicating the number of years of teaching experience. This is an example of how one may use a more sensitive measure of teacher quality if a highly quantifiable one can be found, or how a more subjective measure can be incorporatedinto the model with no change in model structure. Thus, the more sophisticated user can bend the model somewhat toward his interpretation, whereas the user following the directions explicitly, can use the model with good results. The same argument can be made in other sections, and should be kept in mind.

Mathematically, the input variables are combined as follows:

$$TCHQAL_j = (TQW_{1,j} \cdot RECEN_j) + (TQW_{2,j} \cdot TCEHEXP_j)$$

where

$TCHQAL_j$	Instructional Quality Index
$RECEN_j$	Recency of Curriculum Material, Subject j
$TCHEXP_j$	Teacher Experience, Subject j
$TQW_{i,j}$, i = 2:	Instructional Quality Weights, Subject j
j:	Subject

Magnitude ranges:

$$1 \geq RECEN,\ TCHEXP \geq 0$$
$$1 \geq TQW_{i_j} \geq 0,\quad 1 \geq \sum_{i=1}^{2} TQW_{i_j} \geq 0$$

Instructional Intensity

Instructional intensity is related to terms that describe the instructional environment. It is dependent on four terms: the teacher/pupil ratio; the number of texts per student; the number of desks per student; and the budget for teaching aids.

$$TCHITN_j = (TIW_{1,j} \cdot TCHRS_j) + (TIW_{2,j} \cdot TEXTS) + (TIW_{3,j} \cdot DESKS_j) + (TIW_{4,j} \cdot TCHBUD_j)$$

where

$TCHITN_j$:	Instructional Intensity, Subject j
$TCHRS_j$:	Teacher/Pupil Ratio, Subject j
$TEXTS_j$:	Texts/Pupil Ratio, Subject j
$DESKS_j$:	Desk/Pupil Ratio, Subject j
$TCHBUD_j$:	Budget for Teaching Aids, Subject j
$TIW_{i,j}$ i = 1, 4:	Instructional Intensity Weights, Subject j
j:	Subject

Magnitude ranges:

$$1 \geq TCHRS,\ TEXTS,\ DESKS,\ TCHBUD \geq 0$$
$$1 \geq TIW_{ij} \geq 0$$
$$1 \geq \sum TIW_{ij} \geq 0$$

Instructional Duration

Instructional duration measures the relative amounts of time during which students are exposed to instruction. It is represented by indices for the numbers of hours per day, days per week, and weeks per year that the student spends under instruction.

$$TCHDUR_j = (CTHRS_j \cdot TCHDYS_j \cdot TCHWKS_j)$$

where

$TCHDUR_j$:	Instructional Duration Index, Subject j
$CTHRS_j$:	Number of Hours/Day Spent Teaching Subject j
$TCHDYS_j$:	Number of Days/Week Spent Teaching Subject j
$TCHWKS_j$:	Number of Weeks/Year Spent Teaching Subject j
j:	Subject

Magnitude ranges:

$$1 \geq CTHRS,\ TCHDYS,\ TCHWKS \geq 0$$

Instruction Index

The instruction index combines three factors computed in previous sections: Instructional Quality, Instructional Intensity, and Instructional Duration. The three factors are combined linearly to produce the final result.

$$C_j = TW_{1,j} \cdot TCHQAL_j) + (TW_{2,j} \cdot TCHITN_j) + (TW_{3j} \cdot TCHDUR_j)$$

where

C_j:	Instruction Index, Subject j
$TCHQAL_j$:	Instructional Quality Index, Subject j
$TCHITN_j$:	Instructional Intensity Index, Subject j
$TCHDUR_j$:	Instructional Duration Index, Subject j
$TW_{i,j}$, i = 1, 3:	Instruction Weights, Subject j
j:	Subject

Magnitude ranges:

$$1 \geq \text{INSTRU, TCHQUAL, TCHITN, TCHDUR} \quad 0$$

$$1 \geq TW_{ij} \geq 0$$

$$1 \geq \sum_{1=1}^{3} TW_{ij} \geq 0$$

SERVICE

<u>Service Quality</u>

Service quality is measured by two factors - whether or not the service is free, and whether or not the service is new. A program providing a new service will, in general, have a much greater effect on the target group. A free program will, in general, reach more members of the target group.

$$SERQAL_j = (SQW_{1j} \cdot NEW_j) + (SQW_{2j} \cdot FREE_j)$$

where

$SERQAL_j$:	Service Qualtiy Index, Service j
NEW_j:	1 if Program is New; 0 if Otherwise, Service j
$FREE_j$:	1 if Program is Free; 0 if Otherwise, Service j
$SQW_{i,j}$ i=1,2:	Service Quality Weights, Service j
j:	Service Project

Magnitude ranges:

$$NEW, FREE = 0 \text{ or } 1$$

$$1 \geq SQW_{ij} \geq 0$$

$$1 \geq \sum_{i=1}^{2} SQW_{ij} \geq 0$$

Service Intensity

The resources that the school allots to a service are a measure of its intensity, assuming, of course, that the resources are actually applied to the students. Three variables are used to represent the effect: the number of paraprofessionals devoted to the service (clerical aids, counselers, etc.), the amount of space for the service, and the budget for the service.

$$SINTEN_j = (SIW_{1,j} \cdot PARA_j) + (SIW_{2,j} \cdot SPACE_j) + (SIW_{3,j} \cdot SBUDGT_j)$$

where

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$SINTEN_j$:	Service Intensity Index, Service j
$PARA_j$:	Paraprofessional/Student Ratio, Service j
$SPACE_j$:	Space/Student Ratio, Service j
$SBUDGT_j$:	Materials for Service Budget/Student Ratio, Service j
$SIW_{i,j}$ i=1, 3:	Service Intensity Weights, Subject j
j:	Service Project

Magnitude ranges:

$$1 \geq PARA, SPACE, SBUDGT \geq 0$$

$$1 \geq SIW_{ij} \geq 0$$

$$1 \geq \sum_{i=1}^{3} SIW_{ij} \geq 0$$

Service Duration

Service duration measures the relative amounts of time students are exposed to the services offered. The number of hours per day, days per week, and weeks per year are used to compute this index.

$$SDURAT_j = (SHOURS_j \cdot SDAYS_j \cdot SWEEKS_j)$$

where

$SDURAT_j$:	Service Duration Weights, Service j
$SHOURS_j$:	Number of Hours/Day Spent on Service j
$SDAYS_j$:	Number of Days/Week Spent on Service j
$SWEEKS_j$:	Number of weeks/Year Spent on Service j
j:	Service Project

Magnitude ranges:

$$1 \geq SHOURS, SDAYS, SWEEKS \geq 0$$

Service Index

The service index is computed by combining the Service Quality, Service Intensity, and Service Duration linearly to produce a service index for each service offered. The service indices are then combined linearly and weighted to give a final overall measure of service involving all of the service components.

$$SERVIC = \frac{1}{N} \sum_{j=1}^{N} SPW_j \; [(SW_{1,j} \cdot SERQAL_j) + (SW_{2,j} \cdot SINTEN_j) + (SW_{3,j} \cdot DURAT_j)]$$

where

SERVIC:	Service Index
N:	Number of Services Offered
SPW_j:	Service Project Weight, Project j
$SERQAL_j$:	Service Quality Index, Project j
$SINTEN_j$:	Service Intensity Index, Project j
$SDURAT_j$:	Service Duration Index, Project j
$SW_{i,j}$ i = 1,3:	Service Component Weights, Project j
j:	Service Project

Magnitude ranges:

$$1 \geq SERVICE, SERQAL, SINTEN, SDURAT \geq 0$$

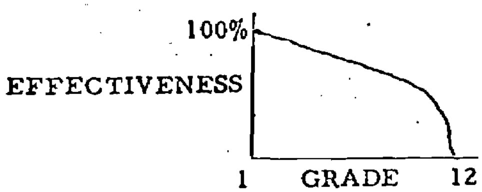
$$1 \geq SPW_j, SW_{ij} \geq 0$$

$$1 \geq \sum_{j=1}^{N} SPW_j, \sum_{i=1}^{3} SW_{ij} \geq 0$$

$$N \leq 5$$

SERVICE EFFECTIVENESS

A service program offered by the schools' attempts, in terms of the language of the model, to reduce students' impedance. How effective the program is in achieveing this result depends not only on its contents, but also on the point in time at which the student is able to use it. For example, a vision problem corrected early in a child's school career may have little debilitating effect on his performance. The same problem, corrected later in his career, may cause a retardation in performance that is too great to be rectified before graduation. This time effect must be taken into account. Graphically, the effect may appear as follows:



Program effectiveness also depends upon the severity of the student's impedance. Thus a graph similar to the one above may be drawn with impedance on the horizontal axis.

An empirical formula was derived to model the effect:

$$EFFECT = \frac{SERVIC - OLDSER}{1 + \left(\frac{GRADE - 1}{OLDZ}\right)^2}$$

where

EFFECT	=	Service Effectiveness
SERVIC	=	Service Level Index
OLDSER	=	Service Level Index of Pre-Compensatory School Programs
GRADE	=	Grade in School
OLDZ	=	Pre-Compensatory Impedance of the Student Population

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Magnitude ranges:

$$1 \geq \text{EFFECT, SERVIC, OLDSER} \geq 0$$
$$12 \geq \text{GRADE} \geq 1$$
$$7 \geq \text{OLDZ} \geq 1$$

SERVICE RELEVANCE

Service programs may or may not affect certain of the factors of disadvantage of the students. For example, free health service attacks the handicap problem, but does not affect the problem of having uneducated parents. Home-school liaisons and parental counseling have the opposite properties.

There must thus be some way of indicating whether a disadvantage is likely to be reduced by the set of service programs offered in the school. For this, the relevancy factors REL_i; $i = 1, 6$ are used. If there is some relevance of service to disadvantage factor i, then $REL_i = 1$; if not, then $REL_i = 0$.

IMPEDANCE

Impedance Index

The target population is characterized by a set of six factors of disadvantage which, when aggregated, constitute its impedance to instruction. Impedance is expressed as an index of values between 1 and 7, and is denoted by the letter Z. When operated upon by the appropriate service components of a compensatory project, Z decreases; the amount of decrease constititues the service's contribution to improved achievement rate.

Impedance is then a combination of service, (through EFFECT), relevance, and disadvantage factors.

$$Z = 1 + [ZW_1 \cdot DIS_1 \cdot (1 - EFFECT \cdot REL_1)$$

$$+ ZW_2 \cdot DIS_2 \cdot (1\text{-}EFFECT \cdot REL_2)$$
$$+ ZW_3 \cdot DIS_3 \cdot (1\text{-}EFFECT \cdot REL_3)$$
$$+ ZW_4 \cdot DIS_4 \cdot (1\text{-}EFFECT \cdot REL_4)$$
$$+ ZW_5 \cdot DIS_5 \cdot (1\text{-}EFFECT \cdot REL_5)$$
$$+ ZW_6 \cdot DIS_6 \cdot (1\text{-}EFFECT \cdot REL_6)$$

where

Z: Impedance

DIS_i: Fraction of the Population having Disadvantage Factor i.

i=1: Parents' Income $\leq$ \$3,000 per year.

i=2: Parents' Education Only Elementary or Less.

i=3: Student Has Physical Handicap

i=4: Student's Family is Disrupted

i=5: Achievemnt Lag of the Student's Classmates $\geq$ 3 is Grade Levels by the 12th Grade

i=6: Student's own achievement lag is $\geq$ 3 grade levels by the 12th Grade

EFFECT: Service Effectiveness

REL_i: Relevance of the Services to the ith Impedance Factor

ZW_i, i=1,6: Impedance Weights

Ranges:

$$7 \geq Z \geq 1$$
$$1 \geq DIS, EFFECT \geq 0$$
$$REL : 0 \text{ or } 1$$
$$1 \geq ZW \geq 0$$

Note that the sum of the ZW's need not be less than one, as it must be with all the other weighting coefficients.

CHANGES IN IMPEDANCE

In reality, even if the most effective possible program were used, one would not expect to dissipate all of the student population's impedance in a single application of the program. There is an upper bound on the

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amount of impedance change that could be expected in the target population after exposure to a program for one year. It is further assumed that this upper limit is directly related to the baseline impedance. The greater the impedance, the greater the potential impedance change, all other variables being constant.

A student possessing all six factors of disadvantage is subject to a maximum rate of impedance decline. Lesser "baseline" impedances yield lesser maxima.

The equation describing the maximum rate of decline is:

$$\text{MAXCNG} = \frac{Z - \text{ZMIN}}{6\,[\,+\,Z^2/(2\ .\ \text{ZMAX}^2)]} \qquad \frac{Z - \text{ZMIN}}{6\,(\dfrac{Z^2}{2\ .\ \text{ZMAX}^2})}$$

Here ZMIN = 1, and ZMAX = 7.

This is compared with the computed change in the impedance, Z-OLDZ, where OLDZ is the baseline impedance value. The maximum of Z, the computed value, and OLDZ + MAXCNG is taken to be the new impedance, Z.

ACHIEVEMENT

Achievement Rate

In a given grade, let us represent the achievement level by A, the achievement rate by S, the level of instruction by C, and the impedance by Z. The period of time between achievement testing and during which the compensatory programs are operating is DYEAR long.

The basic assumption relating achievement to instruction and impedance is that the achievement rate index is directly proportional to instruction and inversely proportional to impedance.

$$S = \frac{C}{Z}$$

"Differentiating" the above equation, we obtain

$$DS = \frac{1}{Z}\ \ (DC - \frac{C}{Z}\ DZ)$$

where

DS: Change in Achievement Rate Index

DC: Change in Instruction Level

DZ: Change in Impedance Level

The changes noted are variations from the baseline levels.

Suppose that we are dealing with blocks of grade such that the IG-th block is $DYEAR_{IG}$ years in length. Successive DYEAR's may have differing lengths. Input variables are measured at the beginning and end of each block. The nominal grade level at the beginning of the IG-th time block is $GRADE_{IG}$. The achievement lag at the same time is therefore $GRADE_{IG}$-A. In order to overcome the entire achievement lag in a given subject within a period of DYEAR years, the population would have to progress at an average rate of

$$SMAX = \frac{GRADE_{IG} - A}{DYEAR_{IG}}$$

grade levels per year. Given intensive compensatory attention, an individual disadvantaged pupil might well maintain or even surpass this rate of achievement, and thus emerge from the program with achievement above general norms. For populations of disadvantaged pupils, though, there is a ceiling effect: one cannot realistically expect to do better than bring them up to the level of their peers.

SMAX represents the greatest possible average achievement rate over the period $DYEAR_{IG}$. SLAST represents the average achievement rate over the previous period DYEAR 0. Intervention undertaken at the beginning of the current period changes the rate from SLAST to S; that is, there is a change in achievement rate due to intervention processes equal to:

$$DS = S - SLAST$$

The greates possible value of DS is thus:

$$= \frac{GRADE_{IG} - ALAST}{DYEAR_{IG}} - SLAST$$

The model assumes that, in order to achieve this maximum change in achievement rate, intervention must: (1) compensate entirely for all deficiencies in quality, intensity, and duration of instruction; and (2) eliminate all impedance resulting from disadvantage. An ideal program of intervention is one that accomplishes these tasks completely, though real programs will accomplish them only partially. Using information about the effects of intervention or instruction and impedance, the model computes an index that represents the fraction of the ideal that a real program attains. This index is the quantity DS derived theoretically earlier in this section. The achievement rate change actually attained by intervention is called DS_{IP}, and is given by:

$$DS_{IP} = DS \cdot DS_{max}$$

$$= \frac{1}{Z} (DC - \frac{C}{Z} DZ) \cdot \frac{GRADE_{IG} - ALAST}{DYEAR_{IG}} - SLAST)$$

Meanwhile, the normal, status-quo forces of maturation and usual instruction have also been producing achievement rate. The School Flow Submodel, which will be described in the following chapter, simulates these processes, that is, it predicts an achievement rate due to the normal processes, S_{SF}. Thus, we can compute an achievement rate change due to normal processes:

$$DS_{SF} = S_{SF} - SLAST$$

The total achievement rate change is the sum of the two effects:

$$DS_{TOT} = DS_{SF} + DS_{IP}$$

and the new state S (held as SLAST for the next iteration) is

$$S = SLAST + DS$$

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This rate S is then the average rate at which the population progresses over the period $DYEAR_{IG}$, so that the new achievement level at the end of the group of years being examined is:

$$A = ALAST + S \cdot DYEAR_{IG}$$

III.4 THE SCHOOL FLOW SUBMODEL

This submodel simulates the normal (without compensatory programs) educational process and transfer of students from grade to grade until they reach their last year of schooling. Thus it performs a two-fold function. The student population's "baseline" achievement level is described, and the effects of the baseline programs plus those of incremental compensatory education programs (determined by the Intervention Submodel) are projected into the future. Alternative compensatory programs will result in different projections, implying different dropout and truancy rates, and different expected lifetime earnings and benefits to the community. Thus, the administrator faced with a choice among a variety of programs will see the long-term effects of his decision.

The information gained from a grade-by-grade indication of potential changes in achievement levels can provide policy planners with better insight into the effects of Title I Programs. It is important to know the residual as well as the immediate effects of a proposed program; for example, one program for second graders may raise achievement levels for only a year, while the effects of another may still be noted six years later. Grade-by-grade achievement records are also useful in estimating and prediciting dropout and truancy rates. As will be shown later in this section these predictions rely heavily on achievement measures. Educators and analysis, because of their familiarity with grade-by-grade achievement data, should be able to utilize these projections without difficulty.

In the previous section we discussed the model used to describe the effect of a given compensatory education program on the achievement levels and achievement rates of students during that program's operation. How, then, does one describe the transitions of the students between various achievement levels from grade to grade? The explicit relationships between instruction, service, impedance, and achievements are not important in this process. We are more interested in describing

empirically the student transitions among achievement levels from grade to grade, without taking into account variables which are undergoing changes; the effects of these changes will have been computed by the Intervention Sbumodel. An implicit method is needed here, one grounded in empirical data and highly descriptive of the grade-to-grade flow of students.

Such a method was designed and described in Design for An Elementary and Secondary Education Cost-Effectiveness Model, Abt Associates, Inc., U. S. Office of Education Contract OE 1-6-001681-1681. The model uses conditional probabilities to predict the achievement pattern in a given grade from the achievement pattern in the previous grade. The student population is characterized according to the percentages of students progressing at rates above or below national, regional, district, or other medians in various achievement categories. For example, one district may have a population distributed in the following manner:

20% progressing at a below median rate in math and reading

10% progressing at an above median rate in math, but at a below median rate in reading

30% progressing at a below median rate in math, but at an above median rate in reading

40% progressing at an above median rate in both.

This description comprises 100% of the population, each member falling into one and only one category. Each of the rew groups in the example above represent a "state". The reasons for using achievement rates as our criterion will be discussed shortly. The number of states is determined by the number of achievement categories. If there are r achievement categories (subjects, usually), then the number of states is equal to 2^r, so that

for 1 category, there are 2 states
for 2 categories, there are 4 states
for 3 categories, there are 8 states
etc.

On the average, a certain percentage of the students in one state pass to another state in the following (or a later)grade. For example, 40% of the students who were progressing at an above-median rate in the fifth grade may be achieving at an above-median rate in reading but at a below-median rate in math in the seventh grade. These probabilities are defined for each grade-to-grade transition, and for all subject combinations, above and below median rates, in each grade. The number of students passing any combination of subjects in the following grade is predicted from: (1) the transitional probabilities for the preceding grade, and (2) the number of students in the state of each combination of subjects in the current grade.

It is clear that several criteria for the "states" could be used: comparison with median scores on achievement tests, passing or failing as indicated by teacher grades, and rate of yearly progression of achievement increase, are a few. Experience in collecting data has indicated that a measure based on achievements, or achievement test scores, should be used instead of teachers' grades for several reasons: (1) the "core" courses all but disappear in junior high and high school; (2) teachers tend to "grade on the curve," thereby eliminating any firm base of comparison between classes; and (3) collection of teachers' grades is sometimes extremely difficult, as school district administrative departments are much more likely to have achievement test data than student grades on hand. The last two problems are often critical, and make teachers' grades of little use in their context.

Achievement test data is, therefore, most practical for our purposes. Achievement levels are reported as output from most achievement tests; to obtain rates of achievement change one must employ finite differences, i.e.:

$$\text{Achievement change per year} = \frac{(\text{Achievement, present test}) - (\text{Achievement, previous test})}{\text{Number of grades between previous and present}}$$

The Intervention Process Submodel requires of the School Flow Submodel the pre-compensatory program achievement rate in each subject or category. As explained earlier, the boost given by the program is not an instantaneous increase in achievement, but rather a quickening of the pace of learning, and, therefore, a positive change in the rate of achievement. This change in rate is added to the old rate to yield a new rate.

For example, if a student has an achievement of 4.0 at grade 5.0, and is thereafter achieving at the rate of only 0.5 grade levels per year, he would be achieving 5.0 in grade 7.0, 6.0 in grade 9.0, etc. Given a boost in rate of 0.25 grade levels per year, he would have a resultant rate of .75 grade levels per year, and his achievement would be 5.5 in grade 7.0, 7.0 in grade 9.0, etc.

Thus, the choice of the criterion for the states must be commensurate with this rate calculation. That is, we must be able to calculate from the states the probabilities or proportions of the population achieving at above or below the threshold rate in a given subject or category. A numerical example will show how this is done. "Above" and "below" refer to achievement rates greater than or less than normal rate. In this hypothetical school population:

State Number	State Description		Probability	
	Math	Reading	Value	Symbol
1	below	below	.40	p1
2	below	above	.20	p2
3	above	below	.10	p3
4	above	above	.30	p4

The Intervention process requires of the School Flow process data on the probability of progress from below to above the threshold math, regardless of reading achievement, and in reading, regardless of math achievement. We denote these as P_m and P_r, respectively.

$P_m = P_3 + P_4$, the sum of all probabilities whose states have an "above" appearing in the math column. So,

$$P_m = .10 + .30 = .40,$$

that is, 40% of the population progresses at a faster than average rate in math achievement. Similarly,

$$P_r = .20 + .30 = .50.$$

These quantities, P_m and P_r are the SSF mentioned near the end of the last chapter.

These transition processes are, in fact, examples of transitions following the Markov process. The assumption underlying the Markov transition concept is that the probability of being in a given state during one time period (grade k) is dependent only on the probabilities of being in the various states in the previous time period (grade k-1). The probabilities of transitions from the i^{th} state in grade k-1 to the j^{th} state in k is P_{ij}.

The total probability of ending up in the j^{th} state in Grade i is the product of the probabilities of the transition from state i to state j times the probabilities of being in state i, summed over all the states i of Grade k-1. More briefly, this is

$$P_{j,k} = \sum_{i=1}^{2^{r(k-1)}} P_{ij} \; P_{i,\,k-1}$$

The population of a resultant state is made up of members who have come from all the states of Grade k-1. (Grades are used here only symbolically.) The transition might as well be from grade 3 to grade 5, or any other increment. It is easy to show mathematically that if the transition from k-1 to k is a Markov process for all k of interest, the transition from k-n to k is also one. The matrix of transiton probabilities

$$M = [\, P_{ij}]$$

is a $2^{r(k-1)}$ by 2^{rk} matrix

We can think of the process symbolically as follows: (let us switch to an n-year jump between grades)

group of states in grade k-n	Operated on by M →	group of states in grade k

Mathematically, if the list of state probabilities is a row vector, then

$$(p_1 \ p_2 \cdots p_{2^{r_{k-n}}})_{k-n} M = \begin{pmatrix} p_1 \\ p_2 \\ \vdots \\ p_{2^{rk}} \end{pmatrix}_k$$

or $\overrightarrow{PP}_{k-n} \cdot M = \overrightarrow{PP}_k$

A numerical example of the process follows, in this hypothetical situation, there is one category of achievement rate in the sixth grade (overall achievement), and two in the third grade (math and reading). States are labelled "below" for lower than median achievement rates, and "above" for greater than median rates.

State Number	Math	State (3rd Grade) Overall Index	Probability	% in-state
1	below	below	.40	40%
2	below	above	.20	20%
3	above	below	.10	10%
4	above	above	.30	30%

	State (6th Grade) Overall Index		
1	below	?	?
2	above	?	?

The empirically determined transition probabilities are computed from past results such as:

80% of students in state 1_{3rd} have gone to state 1_{6th}

5% of students in state 2_{3rd} have gone to state 1_{6th}

etc.

This gives

$$M = \begin{bmatrix} .8 & .2 \\ .05 & .95 \\ .35 & .65 \\ .2 & .8 \end{bmatrix}$$

ie

	3rd — 6th		3rd — 6th
80%	1 — 1	20%	1 — 2
5%	2 — 1	95%	2 — 2
35%	3 — 1	65%	3 — 2
20%	4 — 1	80%	4 — 2

Thus, the state probabilities of grade 6 are:

$$\begin{matrix} .4 & .2 & .1 & .3 \end{matrix} \quad \begin{bmatrix} .8 & .2 \\ .05 & .95 \\ .35 & .65 \\ .2 & .8 \end{bmatrix}$$

$$= \begin{bmatrix} (.8 \times .4) + (.05 \times .2) - (.35 \times .1) + (.2 \times .3) \\ (.2 \times .4) + (.95 \times .2) + (.65 \times .1) + (.8 \times .3) \end{bmatrix}$$

$$= \begin{bmatrix} .425 \\ .575 \end{bmatrix}$$

If we carry out this process from the first grade group in which compensatory programs appear to the last grade group in the schooling process, we will have at each intermediate state a description of the school population for the type of student being investigated. This represents a means of projecting student performance through the entire schooling process. Operating simultaneously for every grade group to grade group transition is the intervention process, which calculates the achievement boosts effected by the compensatory programs.

III. 5 DROPOUT AND TRUANCY SUBMODEL

This section deals with failure to use educational services provided, as manifested in dropout and truancy rates. Other forms of course exist: hostility to such a degree that the teacher is simply tuned out and destructive rebellion are all too familiar examples. We have selected dropout and truancy rates, as these phenomena are readily observed and quantified and can be affected palpably by compensatory programs. Moreover, dropout rates are used in a subsequent part of the model, where their effects on the earning potential of the students are studied. While it seem obvious, it is perhaps worth noting that changes in dropout rates can be expected to alter the load placed on the school plant and faculty in a district. To avoid overcrowding, consideration should be given to the possible effects of Title I Programs on the number of students in school.

Although the legal definitions of truancy and dropout vary from district to district, certain general principles are consistent. Truancy can be considered as the absence from school of a child of school age without parental knowledge. Unverifiable medical excuses and absences to care for sick relatives seem to comprise a large portion of these unlawful absences. Legally, unlawful detention at home of children by parents does not constitute truancy, but the frequency of such unlawful absence is probably so minor that no distinction is made in this mode.

A child may not legally drop out of school before he is eligible for working papers. Students may be absent for extended periods before that time without being considered dropouts. The local Board of Attendance usually classifies these children as truants and is responsible for investigating the causes of absence. After a student passes the age at which dropping out is legal, truancy rates may no longer be meaningful, and extended absences can be considered instances of dropping out.

The measurement of truancy and dropout may reflect certain systematic inaccuracies. Classroom attendance reporting or pupil accounting often plays an important role in a school's funding. Some schools receive support as a function of average daily attendance. These schools tend to remove students who were absent, legally or illegally from their rolls, and to re-enroll them upon their return. Absence rates therefore tend to be biased downward. The student case load pressures on Boards of Attendance are frequently exacerbated by the boards' obligation to verify children's absences and to determine their causes. Large case loads may introduce further inaccuracies into the reporting of absences and their causes.

In the construction of the model of truancy and dropout rates, we have utilized the correlation between achievement lag and dropout and truancy rates as the basis for our predictions. Of the variables which affect dropouts and which are subject to the effects of Title I funding, achievement levels are perhaps the most easily quantified and predicted.

In previous sections of this report, the model's close association with achievements, both in the predictive aspect of the Intervention submodel, and in the projections of the School Flow submodel, has been noted. Each student's eventual decision to remain in school or to leave may be influenced by incentives applied years earlier. The most effective means of persuading a student to remain in school may be assistance in raising his achievement level in earlier years.

A potential dropout often feels pressured to leave school when he feels that he is falling steadily further behind the rest of his class, his desire to drop out is likely to increase. This relationship is expressed in the model by the computation of LAG, a quantity representing the distance that students in the i-th grade fall behind the normal achievement levels for that grade. Dropout rates may then be expressed as follows:

$$DROPOUTS_i = B_i^1 \cdot LAG_i + B_i^2$$

where

$DROPOUTS_i$ = Dropout Rate in the i-th Grade

B_i^1 and B_i^2 = Regression Coefficients

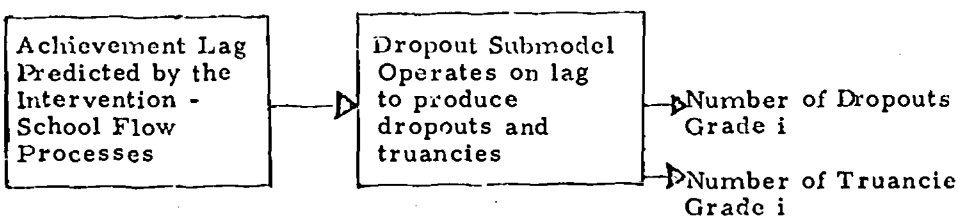
LAG_i = Achievement Lag in the i-th Grade

and i = Grade

Truancy is similarly expresses as

$$TRUANTS_i = C_i^1 \cdot LAG_i + C_i^2$$

The second of these regression coefficients can, in each case, be considered to relate to the number of students who would drop out or be truants whether or not changes in their achievement took place. The subscript i makes each of the above equations express 12 different equations, as the effects of achievement lags differ from grade to grade. The effects of changes in achievement levels in primary grades can thus be extended through the student's life to grade n by n-1 successive applications of the formula, thereby displaying the long-term effects of the programs applied.



The previous form of the equations as described in Design for an Elementary and Secondary Education Cost-Effectiveness Model, Volume I, U.S. Office of Education, was somewhat different from that above. It related the change in the number of dropouts and the change in the number of truancies to the change in achievement due to a compensatory education program. The present form of the model relates the dropouts and truancies per capita to the achievement lag. A change of achievement, whether

caused by the compensatory education program or by the normal schooling process, produces a change in dropouts and truancies. The relationship between the variables is much easier to verify in the present form. The plots shown in Figures III. 5. 1 through III. 5. 4 illustrate this, using data from a California school district. Dropouts and truancies for grades 8 and 11 are plotted against achievement lags. The truancy-achievement lag plots are remarkably linear; the dropout-achievement lag plots are less so.

It does not necessarily follow that achievement lags are causing the dropouts and truancies; other intermediate factors may be operating. The assumption which must here be made is that even if achievement lag is not the direct cause, programs affecting achievement are also affecting those intermediate factors. In fact, dropping out and truancy are probably a direct result neither of achievement lag nor of any other single variable. Until some other relationship is demonstrated, achievement lag will be taken to be the "cause" of dropouts and truancies, or to be at least an approximation of the unknown causes.

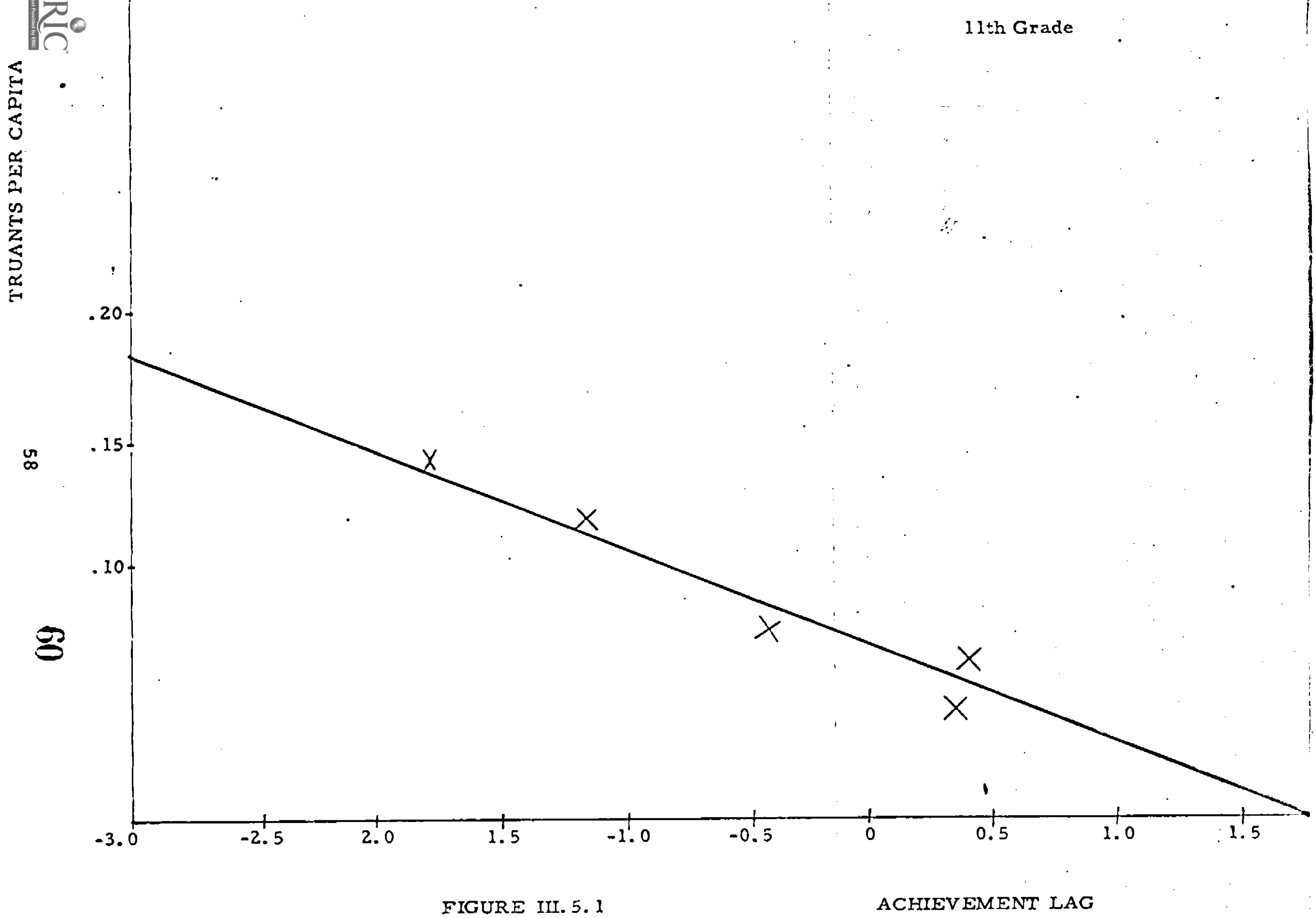


FIGURE III.5.1

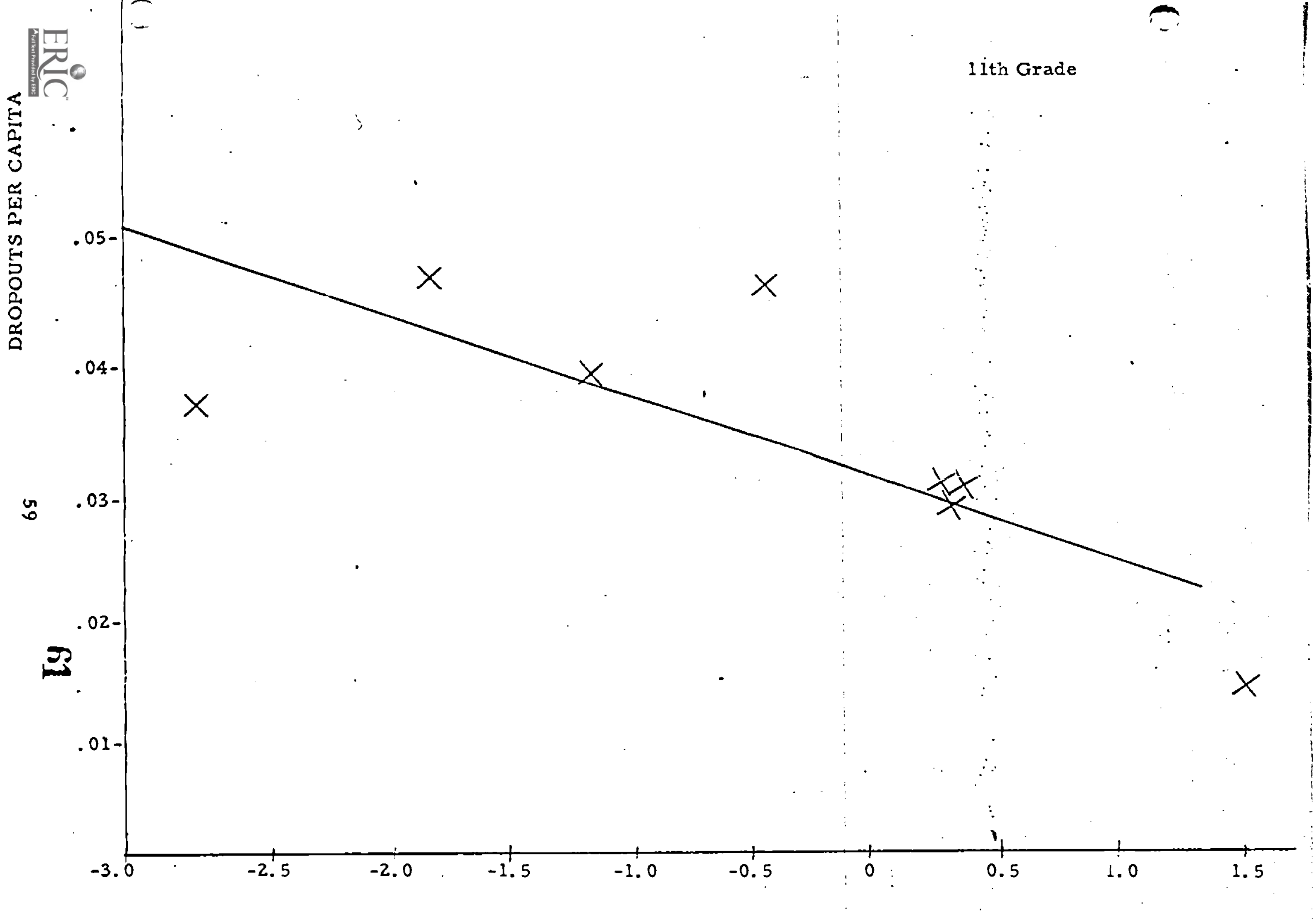


FIGURE III. 5.2

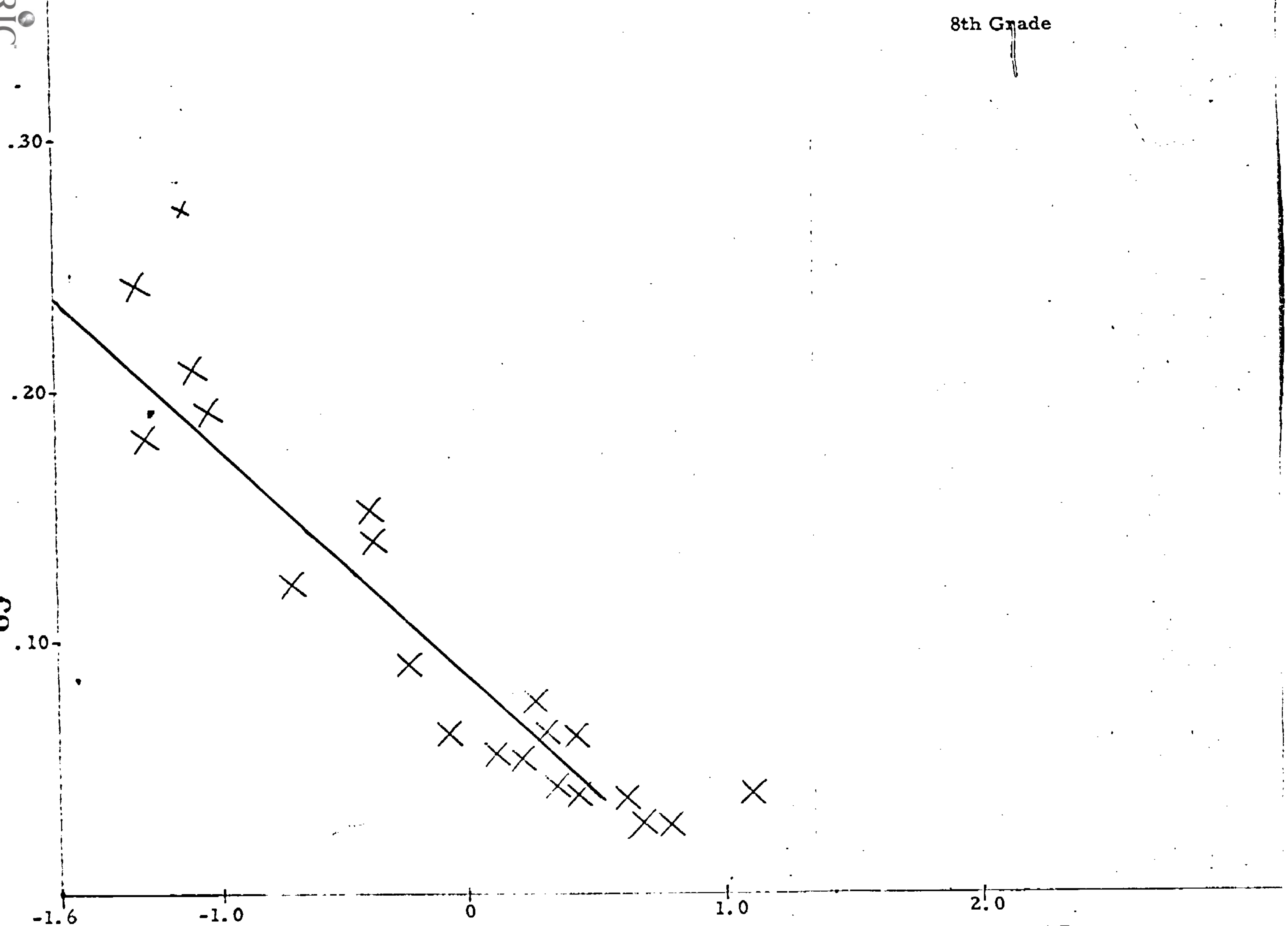


FIGURE III. 5. 3

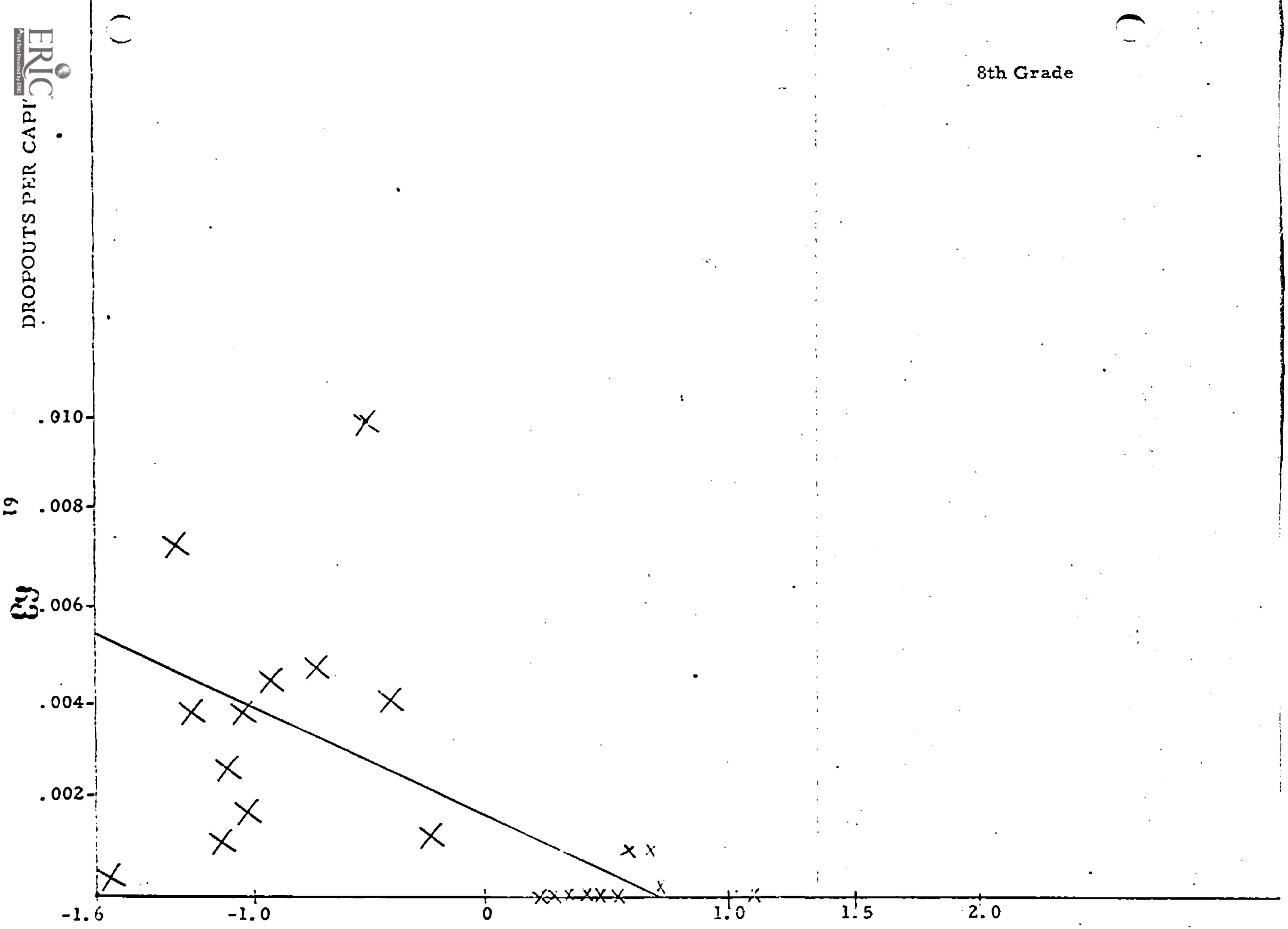


FIGURE III. 5.4

III. 6 COMMUNITY EFFECTS SUBMODEL

Two of the most significant effects on the community of education education are the lifetime earning potential of the student and the equality of educational opportunity. Both of these indices are approached as functions of the length of time a student remains in school and his achievement level when he leaves school. Previous chapters have detailed the effects that educational policy will have on both these factors. Output from earlier parts of the model is sued in the Community Effects submodel to predict the indirect influence of policy on the students' later lives. We have chosen to base our values of income on those given in Employment and Earnings Statistics for the United States (Bulletin No. 1312-2 of the Bureau of Labor Statistics). Employment classifications are grouped by skill levels.

A student's achievement level is significantly correlated with his income, as are his parents' social background and race. Each of the influences named above, except the number of years spent in school, is expressed as a factor whose value in an "average" case is one. This is reflected in Figure III. 6. 1 and in the following equation.

Lifetime Earnings (corrected) = Mean earnings for this educational level or career choice.
x Racial Factor
x Social Factor
x Achievement Factor

where Racial Factor = $\frac{\text{Average income for person of this race}}{\text{Regional Average}}$

Since the racial factors are based solely on the distribution of students among the various types, they depict as accurately as possible the regional differences in racial stratification. The social factors = 1-a (where a is a small number, such as .05) depend upon whether the father's income is above or below the national average.

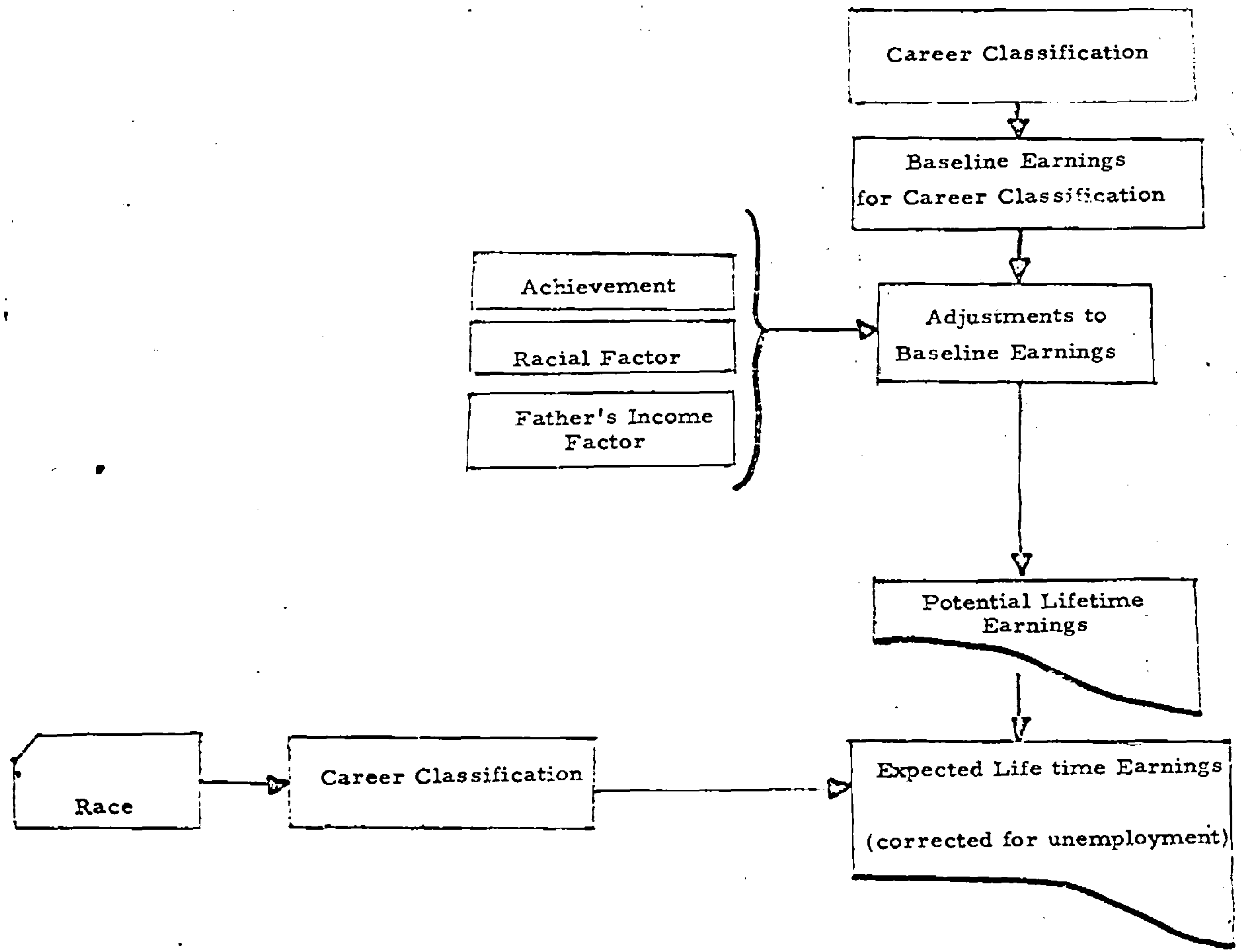


FIGURE III. 6. 1

POTENTIAL LIFE TIME EARNINGS

Achievement Factors are so constructed that a student who is 10% behind his grade level when he leaves school will be penalized by 10% in his income whether he leaves in sixth or twelfth grade.

When a population of students first enters the submodel, it is broken down into classifications by employment categories. Dropouts are classified as Unskilled, Semi-skilled, or Skilled, depending on the amount of time they have remained in school. High school graduates are classified as Academic, Commercial, or Vocational on the basis of the Holland model.* Students in the Academic category are further classified as Entered College and Did Not Enter College.** These classifications are detailed in Figure III. 6.2.

There are two significant factors in a subject's income profile, the number of dollars earned per year, and number of years of earning life. It is desirable to combine these two into one index of Potential Lifetime Earnings. It is not at all clear at the outset, however, just what Potential Lifetime Earnings ought to mean. A major source of difficulty stems from the ambiguity of dollar values. One dollar, withheld from circulation for a year, may, owing to inflation, have a value of only 96¢ when it is returned to circulation. The same dollar, invested in a functioning part of the economy, may be worth $1.06 at the end of the year. As we are dealing with incomes which may be distributed over a span of as many as 40 years, it is important that some account be taken of the possible changes in income value during that time span. To account for changes due to inflation, income figures are uniformly expressed in 1958 dollars using a constant wage index. To account for the difference in value between one dollar now and one dollar at some time in the future, all future incomes have been discounted at 6% per annum starting when the subject leaves school. A parallel series of incomes is provided, taking into account the differing unemployment rates among various educational levels and between Negroes and whites.

The final average value assigned to potential lifetime earnings is

$$\text{PLE} = \sum_i \frac{(\text{potential earnings of i-th career classification}) \times (\text{number or students in i-th classification})}{(\text{Total Number of Students})}$$

*Socioeconomic rank and achievement rank, when weighted equally, provide a predictor of occupational level significant on the 99% level.

**Prediction is on the basis of socioeconomic status and ability rankings.

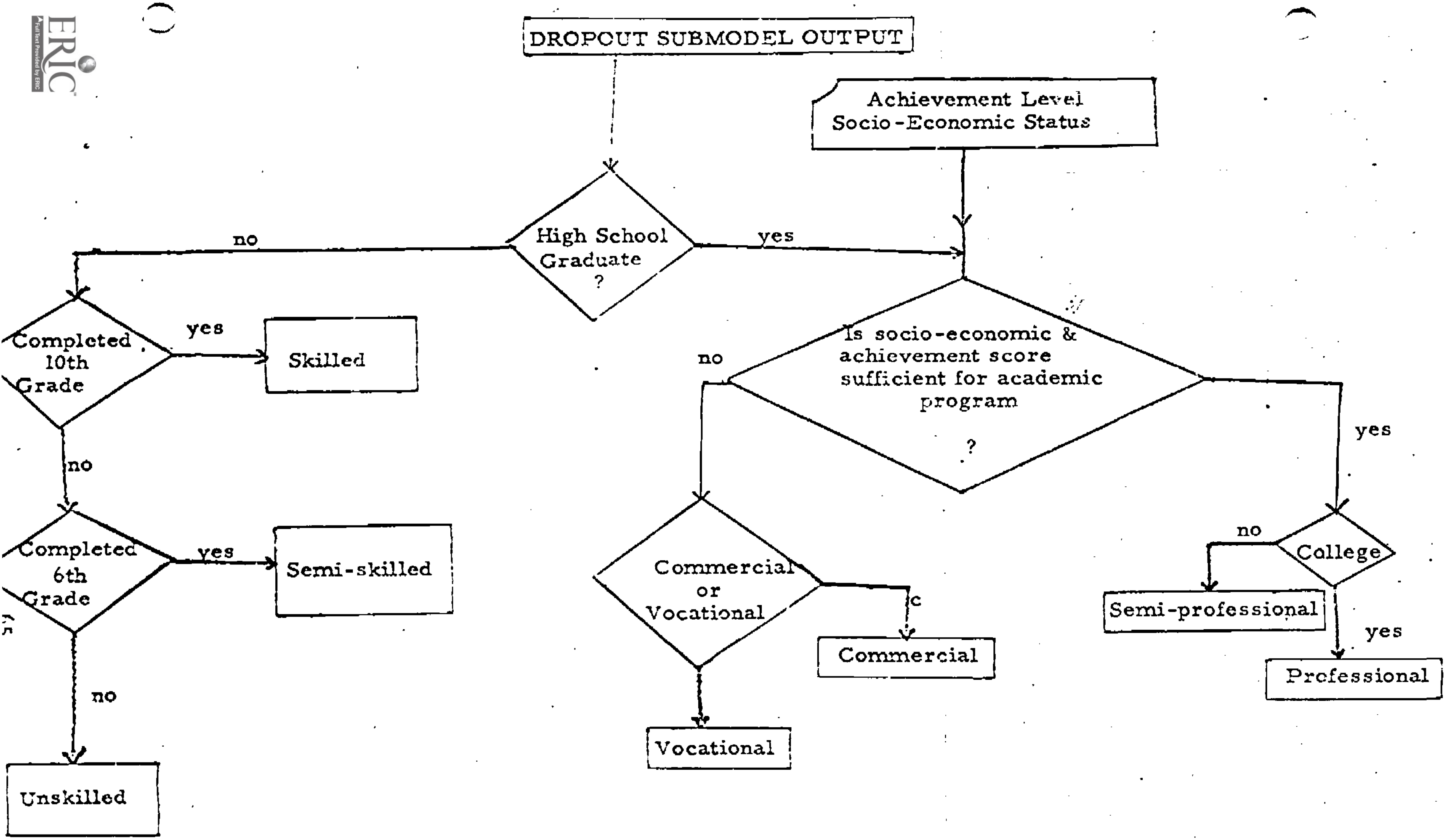


FIGURE III. 6. 2

FLOW CHART OF CAREER CLASSIFICATION

Potential lifetime earnings are predicted in a probabalistic manner. To assess correctly the weight the submodel output should carry in the decision process, it is necessary to know the amount by which the output may be expected to differ from "true" values (those we would predict if complete information about each individual were available). This can be evaluated by standard error propagation methods as follows:

If PLE = f(a, b, ...), $\Delta PLE = [(\frac{\partial PLE}{\partial a})^2 + (\frac{\partial PLE}{\partial b})^2 + \ldots]^{1/2}$.

Compute in this way, PLE =

$$[(15\Delta Y)^2 + (750\Delta N_i)^2 + (150\Delta N)^2 + 10^8] ^{1/2},$$

assuming average values for income and achievement and a total class size of about 500. Allowing 10% relative error for income (Y) and number of students entering each classification (N_i), the estimated standard deviation of PLE is about 25% at mean income values. This means that half the time the PLE will be in error by less than \$13000 and the prediction of annual income will be in error by less than \$800 per year. Since the range of incomes is about \$5000, the most probable error is therefore about 15%.

The only model of occupational decision which can boast any data confirmation at the present time and which is at all general in extent is the Holland model of vocational determination.[10] A detailed account of the formulation of this model is given by Holland. Some statistical validation may be found in a paper by Bruce C. Stockin.[18]

The findings of these two researchers indicate that an estimate of occupational level based on the achievement level and the socio-economic level of the subject is an accurate predictor at the .01 level of uncertainty. Holland suggests that the relevant variable of socio-economic status is in fact the self-image of the subject. In the empirical test, the socio-economic status is a composite variable composed of the father's education, the mother's education, and the father's income. Students were ranked by quartiles in achievement and socio-economic status, and a matrix of occupational levels was produced with occupational level as the elements.

ACHIEVEMENT QUART

		I	II	III	IV
socio-	I	(2)	(3)	(4)	(5)
economic	II	(3)	(4)	(5)	(6)
quartile	III	(4)	(5)	(6)	(7)
	IV	(5)	(6)	(7)	(8)

Matrix elements are Occupational Levels 2 through 8

Students were placed in the correct cell more than 60% of the time, and were misplaced by only one cell about 20% of the time.

The most extensive theoretical study of career determination is probably to be found in Ginzberg and Associates' Occupational Choice[7]. The authors suggest a four-part model of the decision process: 1) reality factors and environment; 2) the influence of education; 3) emotional needs and desires; and 4) value selection. The data base of the study is about 100 case studies, traced through the decision stages over a period of about 20 years.

There exist scattered studies (two or three are published each year) relating socio-economic status to some particular occupational classification. For example, E. K. Eric Gunderson and Paul D. Nelson[8] also find a correlation between socio-economic status (as defined above) and white or blue collar job status among Navy men, significant on the .001 level. (X^2=107.7).

INDEX OF EQUALITY OF EDUCATIONAL OPPORTUNITY

The index of equality of educational opportunity is a measure devised to indicate the degree to which a school system exercises and develops the potential of all students regardless of socio-economic background. The idea for such an index comes from an article by James S. Coleman, who suggests that the measure of equality of educational opportunity is the degree to which each student is equipped at the end of school to compete on an equal basis with others, whatever his social origins.[3] In other words, schools are successful only insofar as they reduce the inextricability of a student's opportunities from his social origins. Equality of educational opportunity implies schooling which will overcome the differences in the starting point of children from different social groups.

In order to compute an index of equality of educational opportunity, it is important to look at the change in achievement differences among student types during their school career. Only to the extent that a proposed Title I Program lessens these achievement differences by the time of graduation does it contribute to increased equality of educational opportunity.

Data available for the model's input are achievement scores for the socio-economic groups to be considered, for first grade and a later grade entrance. These will be symbolized as follows:

Symbol	Meaning	Theoretical Range
A_{i1}	Average achievement level of the most advantaged group (i) at entrance into 1st grade	-2 thr. 12
A_{k1}	Average achievement level of a less advantaged group (k) at entrance into 1st grade	-2 thr. 12
A_{ij}	Average achievement level of the most advantaged group at entrance into jth grade	-2 thr. 12
A_{kj}	Average achievement level of a less advantaged group at entrance into jth grade	-2 thr. 12
j	Grade level at which data are gathered for measurement of equality of educational opportunity	-1 thr. 12

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The model's output is an index with an interval of zero through one, by means of which different schools and school systems may, using a percentile scale, compare their relative success in improving equality of educational opportunity.

The first task in developing the model is to decide what constitutes absolute equality, and absolute inequality of opportunity. It is assumed that there is one socio-economic group which begins with and maintains at least a slightly higher average than other groups. Since a school clearly does not wish to reduce that higher average to the level of the other groups in order to achieve equality of educational opportunity, we can set that average as the standard toward which the school attempts to raise pupils of disadvantaged groups. Perfect equality of educational opportunity, may be considered to exist when the achievement lag of less advantaged groups decreases sufficiently each year for it to be absent by the twelfth grade.

Absolute inequality of educational opportunity is characterized, then, by the greatest lag theoretically possible; in such cases, there is no improvement at all in achievement level through twelfth grade age. Achievement ratings come from verbal and mathematical skill test scores, and there is no reason to assume that some disadvantaged group, through language, cultural, psychological, or other difficulties, might nor score a nearly constant low average throughout the school-age years in a school with little inadequate space, teachers, attitude, insufficient materials, or other severe problems.

These assumptions and definitions can be represented most easily by means of a graph. Figure III.6.3 relates the five input variables to e, chosen to symbolize the index of educational opportunity.

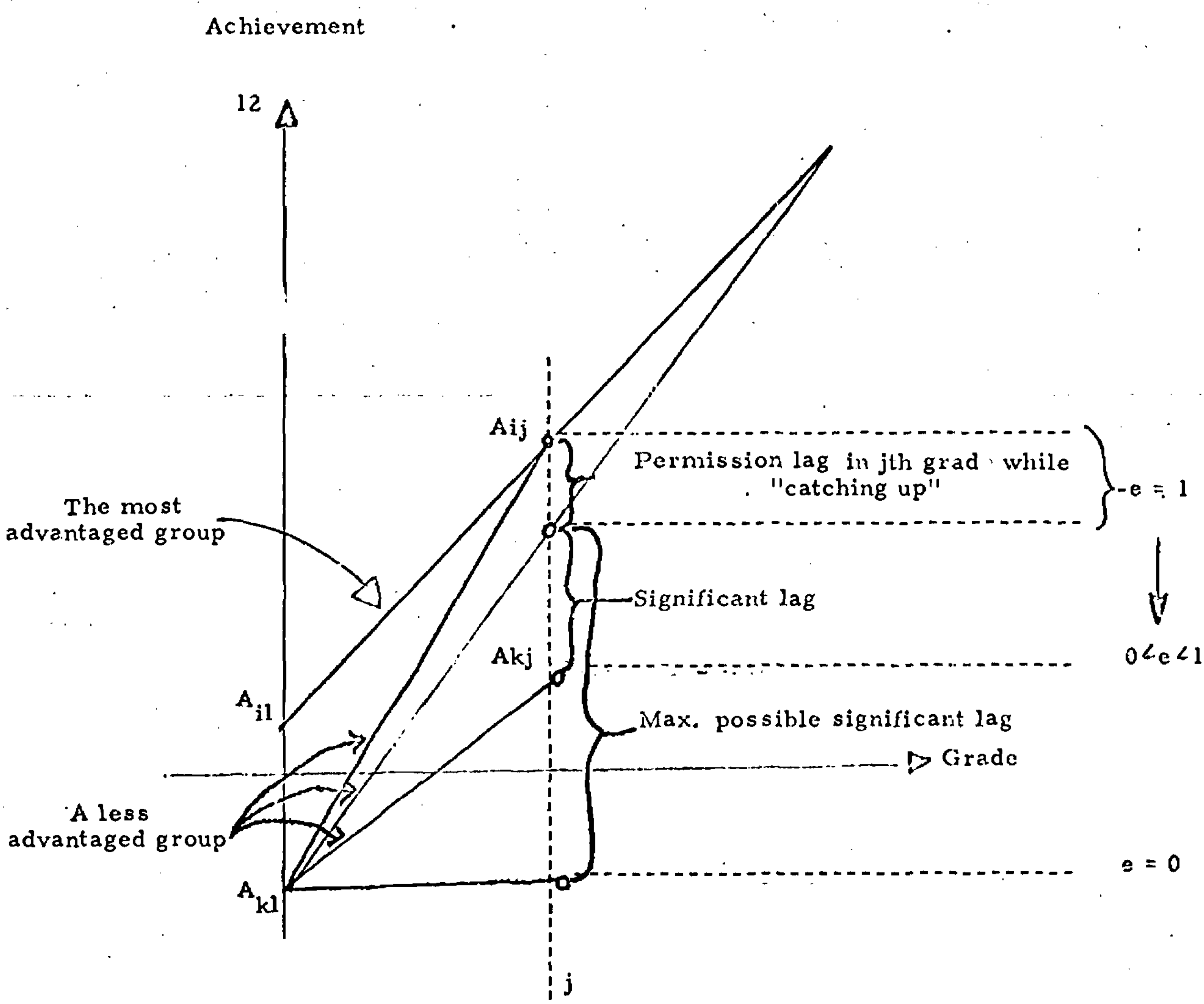

FIGURE III. 6. 3
VARIOUS ACHIEVEMENT PATTERNS VS. GRADES

Since e is arbitrarily set to be between zero and one, and is to be used only for comparison and percentile purposes, it need only be the smallest possible linear function of the input variables to produce the characteristics given by the above assumptions and the graph. Thus, for e to vary as shown,

$$e = 1 - \frac{\text{significant lag}}{\text{maximum possible significant lag}}$$

More specifically, letting

$$P = \text{permissible lag} = \left(\frac{12-j}{11}\right) \quad (A_{11} - A_{k1})$$

from the graph we have

$$e_j = 1 - \frac{A_{ij} - A_{kj} - P}{A_{ij} - A_{k1} - P},$$

or finally,

$$e_j = \frac{A_{kj} - A_{k1}}{A_{ij} - A_{k1} - P},$$

with the addition that if the right side of the equation is greater than 1, $e = 1$. e_j is the index measured in the jth grade.

An example will demonstrate the use of the model, and the reasonableness of its outputs.

Suppose the most advantaged group in a school enters first grade at an achievement level of second grade, and a less advantaged group enters an achievement level of the first grade. We look at this same class in sixth grade, to find that the more advantaged group has a grade level of 6, and test the model with less advantaged levels in the sixth grade of sixth, fifth-and-a-half, fifth, fourth, third, second, and first.

Given: $A_{i1} = 2$, $A_{k1} = 1$, $A_{ij} = 6$, $j = 6$

If:	$A_{kj} = 6$	5 1/2	5	4	3	2	1
Then:	e = 1	1	44/49	33/49	22/49	11/49	0

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e is calculated for each class in each grade and for as many significant different socio-economic groups as desired, and may then be compared by simple percentiles with data from other schools.

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III. 7 THE OUTPUT SUBMODEL

The output submodel is a subroutine which reorganizes the results of the preceding submodels and organizes it into a concise and easily interpretable form, containing the critical variables needed for evaluation. Comparison of the results of a baseline run with the results of a compensatory program, or between alternative compensatory programs, can be systematically and easily accomplished. The relevant quantities are displayed in exactly the same form in each case.

The output is designed to be concise, so that the user is not overwhelmed with voluminious or incomprehensible results. The quantities indicated for each type of student are the following:

by grade --

English Achievement, Math Achievement, number of truants, number of drop-outs.

Overall --

Numbers in various socio-economic strata and their expected and potential lifetime earnings. The index of equality of educational opportunity.

A sample of this output is shown in Figure V-12. One sheet of these results occurs for each student type, so that comparisons across types, as well as among programs for a given type, are possible.

CHAPTER IV

ESTIMATING PARAMETERS OF THE OECE MODEL

INTRODUCTION

Social Systems change; explanations of the causes and processes of change are the basis of all social theory. It is an obvious corollary to this fact that the empirical relationship between any two variables does not remain constant over time. The relationship changes as other factors affecting the variables change.

One of the most interesting types of relationship modifications occurs when knowledge of the relationship and its processes is imported to people operating in the social system. The first and clearest evidence of this type of affect came in economic research describing parameters and relationships between variables in a market situation. Publication of findings changes the parameters in the market, because people use the information to try to operate more effectively in the market.

Educational systems are no doubt quite similar to other social systems in these respects. Empirical relationships between variables change over time. Even if educators did not try to gain knowledge about educational relationships, the future parents schooled within the educational systems and political and technological changes in the society would change the empirical relationship. Educators are, of course, trying desperately to influence the educational process.

A second and related point concerns differences between semi-autonomous educational systems which are operating at the same point in time. There is every reason to expect that the empirical relationship between the same variables in different educational systems at the same point in time differ in manner, although probably not to the same degree that the relationships differ over time. This is likely because social conditions and knowledge input can and do differ among systems at the same point in time, just as these factors change within a system over time.

To the extent that a model of a system is based on empirical relationships among variables, rather than rationally chosen and tried relationships as in systems engineering, the model must be considered static. Although the model could be projected over time, the basis of projection depends on accurate knowledge of empirical relationships at several points in time. Projection of changes in these relationships, though possible in some cases, is a hazardous and usually unfeasible endeavor, especially since it is difficult to estimate the effect that knowledge gained from the model, whether correct or incorrect, will have on the process being modeled. In addition, it is apparent that a model used for a number of different but closely related systems must have as one parameter a relationship between types of systems and parameters of relationships within that system. When such information is unavailable, or when no such definite relationship among different examples of the basic system exists, it is necessary to make different estimates of relationship parameters for different situations in which the model is used.

These qualifications do not mean that model building is useless, but are rather intended to provide a realistic approach to the development and use of models which are designed to reflect hybrid social processes. It is necessary to realize that: (1) "solution" or permanent statement of model relationships is an unattainable goal in an evolving social situation; (2) a model is only good as the information which is used to set its relationships. Such information should therefore be as recent and as accurate as possible, and should reflect characteristics of the specific system for which it is used; (3) refinement of the present OECE Model and development of more sophisticated models to replace it depend heavily on the output of basic research in education. The present model is, in many ways, more differentiated and elaborate than the information which is used to set its parameters. It is the lag in educational research information, rather than any lack of modeling capabilities, which is at present a constraint on model development. When better information on the nature of relationship between educational variables becomes available, the

the present model can be adapted to take such information into account (see Appendix C). In short, use of the OECE Model requires adaptation of the parameters to fit system variants. It also demands constant review of model relationships and actual relationships to detect changes resulting from changing social forces and from the inclusion in the system of greater knowledge of its workings.

NATURE OF THE OECE MODEL AND ITS PARAMETERS

The Office of Education Cost-Effectiveness Model has two basic design advantages by which the evolution of social systems and the need for revision, as discussed above, may be taken into account. The model has, first of all, both external (input) and internal (working) parameters and algorithms. An example will clarify this distinction. The instruction index (C) is a working or internal variable constructed through internal weightings and linear combinations of three other internal variables: instructional quality (TCHQAL), instructional intensity (TCHITN), and instructional duration (TCHDUR). These internal variables are themselves formed by weighting and combination, linear except in the case of instructional duration, of the input or external variables. In the case of instructional quality, recency of curriculum material and teaching experience are component variables. This characteristic of the model permits re-evaluation of the importance of various inputs without modification of the input relationships of the model.

If, for example, teacher experience were, in a hypothetical situation, to become a less significant factor in U. S. educational systems as a result of the decrease in the differences in teacher experience, this change could be modeled externally; less weight would be given to teacher experience and more weight would be given to other factors thought to have instructional value. Such an external modification would not alter the relationship of instructional quality and other internal variables, as long as the external weights were so adjusted.

Alternatively, modification of internal weights would assign

different emphasis to each of the internal variables, of instructional quality, instructional intensity, and instructional quality, instructional intensity, and instructional duration, without altering the manne r in which these variables are constructed from external variables. Even greater modification would be achieved by changing the algorithm by which the instructional index is related to other internal indices.

The design of the model, then, permits modification in any of several ways without altering the algorithm. New information pinpointing specific effects can be included without reworking major internal model assumptions.

A second major, advantageous characteristic of the model is that the value of all variables, both internal and external, ranges from 0 to 1. This permits the use across semi-autonomous systems without adjustment since data must be in some sense comparable before use as input. The more important related advantage of this characteristic is, however, that the parameters estimated for the model become the only basis for estimating the relative importance of different indices, as actual data range is already controlled. The implication of this becomes clear if the difference between a "filled" and an "unfilled" model is considered. In the case of a filled model, all variance in the output of the model is accounted for by the model inputs; there are no cases as, for example, of student achievement, which are accounted for by variables other than model inputs. This situation occurs by definition in each case where the maximum value of the weight sum is 1.0. Those weights are set at values such that their sum is the maximum allowable. In the unfilled model case, at least some weights, the maximum sum of which is 1.0, do not total that. It is also possible for the internal portion of the model to be filled while the external portion remains unfilled.

These two related design characteristics, the external and internal indices and algorithms, and capacity for the model to be filled at one level and unfilled at another, provide a basis for a methodology of estimating the data weights to the OECE Model. This methodology approaches the problem of weight estimation

by studying the external model weights to reflect the current best knowledge of actual relationships, while internal weights are "filled" so as to utilize all external index ability to explain variance in model output.

Where information from educational research is unavailable, it is assumed that lack of information indicates a lack of relationship to achievement. While such an assumption is subject to revision, it is the safest and least biased way of resolving a dilemma stemming from the present paucity of high quality research on the causes of student achievement. In cases where information is available, the external weight is set equal to the proposition of achievement variance explainable by the variable. If that data is not available, but information on similar variables is available, estimation may be made on basis of similar variables. Indices which are internal to the model reflect differential causal effects on different groups of input variables. Estimation for each series of internal weights is designed so that the weights total 1.0. In this manner full use is made of information once it is in the model. The size of each weight for a category of inputs is determined by the proportion of variance subsumed under that category. An example of this procedure is shown in Figure IV. 1. Thus, input weights are determined by research findings, and internal or working weight by the proportion of variance explained by a given index's input; the sum of internal weight equals 1.0.

Two final methodological notes are in order. First, the above method of weight estimation, and for that matter, the OECE Model as presently designed, do not take into account the fact, discussed in the Coleman Report[1], that students of different ethnicity have achievement rates which are differentially sensitive to variations in school quality. This means that a given model weight may itself differ depending upon the ethnic composition of the population for which the model is being

[1] James S. Coleman, et al, Equality of Educational Opportunity (Washington: U. S. Government Printing Office, 1966) p. 297.

used. The model is presently weighted for use within school systems in which Negroes account for 20% of the student population. This is accomplished by attributing appropriate proportional significance to research reports of variance in achievement attained by blacks and by whites. Should the model be used, for example, in a predominantly Puerto Rican school system, the weights for instruction and service indices, as well as impedance, would be increased somewhat, as Puerto Rican pupils are more sensitive to variations in school quality and at the same time have greater barriers to education than do other ethnic groups.

Secondly, the present methodology was developed to best utilize present educational research in the OECE Model. Its major deficiency is that the sum of all external weights is a maximum of 1.0, whereas if information about the relative importance of such internal variables as teacher quality and teacher intensity were known, this under determinancy could be eliminated. The deficiency does not seriously affect model output, as the model does reflect accurately the relative importance of input variables, to the degree that such information is known.

PARAMETER ESTIMATES

The initial setting of weights for the OECE Model is based in large part on the "Coleman Report"[2], the only large scale national study in which the causes of student achievement are considered in a systematic, quantitative fashion. The information from that report is, at times, supplemented by various data from Title I evaluations. In some cases, where information is unavailable or incomplete, certain assumptions are made about the educational process, and estimates of weights are made on the basis on the specified assumptions. All weight estimates and their underlying assumptions should be subject to change and to adaptation to the needs of the individual user (see Appendix C).

[2] Ibid., especially PP. 290-329

SCHOOL FLOW PARAMETER ESTIMATES

The school flow submodel describes the achievement, distribution of students from grade to grade on conditional probabilities (see Chapter III.5). These conditional probabilities are located in the MARKOV Matrix, and are the only parameters of the school flow submodel which have to be estimated. The present estimation is a generalized one based on some empirical findings in a California school district and on certain assumptions about changes in transitional probabilities from one grade level to another. Although the absolute levels and distribution of the transitional probabilities may differ from school system to school system, the assumptions made in the present estimation are probably sufficiently general to be usable in most situations.

The submodel requires a matrix of probabilities of the likelihood that the student will, for example, be above or below a given achievement level in English and Mathematics, on the basis of his performance in each of the courses in the preceding grade (see Figure IV. 2). The sum of probabilities in a row should equal 1.0 if all students make the transition, as all alternative possibilities are present. The California data is used in setting up the Markov Matrix in the first transition. Assumptions are made as to the manner in which major changes are affected from the first to the sixth and last transition:

1. The probability that a student will be below threshhold in both courses in the subsequent grade, if he was below threshhold both courses in the previous grade (FF, FF), increases substantially from the first to the last transition. Thus, failure at one grade increases the probability of failure at a later point.

2. The probability of passing both courses, if both courses were passed in the previous year (PP, PP) increases linearly at a very slight rate from a high base line level.

3. The probability that failure in one course will lead to subsequent failure in that course (FP, FP) or (PF, PF) increases over time. Failure in a subject increased the likelihood of continued failure in that course.

4. If a student fails one course and passes the second, the probability that he will subsequently fail both courses is greater than the probability that he will fail the second and pass the first.

On the basis of these assumptions, the Markov Matrix has been constructed and is presented in Figure IV-3.

INSTRUCTION INDEX PARAMETERS

The beta weights requiring estimation for the Instruction Index include weights of input variables for the Instructional Quality Index and the Instructional Intensity Index, and weights for these internal indices and the Instructional Duration Index, which are combined linearly to form the Instruction Index. Although the OECE Model is designed so that different weights may be assigned for each course and grade, present information permits no differentiation between courses, and only slight differentiation by grade.

There is not usable information available on the impact of recency curriculum material on student achievement. Therefore,

$$TQW_{1,j} = 0.00$$

for all subjects, j, and all grades.

The Coleman Report is on the whole rather pessimistic about the effects of school variables on pupil achievement:

> It is known that socio-economic factors bear a strong relationship to academic achievement. When these factors are statistically controlled, however, it appears that the differences between schools account for only a small fraction of the differences in pupil achievement.[3]

[3]Ibid., PP. 21-22.

After discussing school facilities and curriculum and their lack of relation to pupil achievement, the report continues,

> The quality of teachers shows a stronger relationship to pupil achievement. Furthermore, it is progressively greater at higher grades, indicating a cumulative impact of the quality of teachers in the school on the pupil's achievement. Again, teacher quality seems more important to minority achievement than to that of the majority.[4]

The teacher variable used by the Coleman Report combines a number of variables, including the teacher's family educational level, his years of experience, his own educational level, and his score on vocabulary tests. The OECE TCHEXP weight $TQW_{2,j}$ are based on this variables and on the percent of student achievement gains it explains. $TQW_{2,j}$ is a weighted mean of the percentage variance between teachers of blacks and whites according to the Coleman Report.[5]

Such a procedure provides:

$$TQW_{2,j} = 0.01 \text{ for grades 1, 2, 3, and 5}$$

$$TQW_{2,j} = 0.02 \text{ for grades 6, 8, and 10.}$$

Weights for the Instructional Intensity Index were estimated as follows:

$$TIW_{1,j}$$

$$TIW_{2,j}$$

$$TIW_{3,j}$$

were all subequal to 0.00 for all grades and subjects.

$TIW_{4,j}$ (the weight for TCHTUD-budget for teaching aids) was set at:

$$TIW_{4,j} = 0.01$$

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[4] Ibid., P. 22

[5] Actual data is from Table 3.25.3, in Ibid., P. 319.

for grades 1, 2, 3, 5, and 6.

$$TIW_{4,j} = 0.0$$

for grades 8 and 10.

$TIW_{1,j}$ is to reflect the importance of the teacher/pupil ratio (TCHRS). According to the Coleman Report, that ratio "showed a consistent lack of relation to achievement among all groups under all conditions."[6]

The second Instructional Intensity Index weight indicates the importance of a text/pupil ratio (TEXTS) to student achievement. There is little information on this relationship; that which was available[7] indicated that it had no effect on student achievement.

No information was available concerning the impact of a desk/pupil ratio (DESKS), and the weight for this variable ($TIW_{3,j}$) is therefore set to 0.00.

The only one of the four variables included in the Instruction Intensity Index which does seem to influence achievement is TCHBUD, or Budgets for Teaching Aids. The Coleman Report noted a slight relationship, less than that of the teacher variables, with student achievement. This effect seemed to disappear in later grades.[8]

The third internal instructional variable, of Instructional Duration, requires no weight. It is, therefore, for all purposes a "filled" external variable, and is only weighted internally. The weight of this variable in relation to Instructional Quality and Intensity was weighted at:

$$TW_{3,j} = 0.10$$

The other internal Instructional weight were estimated by the method described in Figure IV-1 yielding:

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[6] Ibid., P. 312

[7] See for example "Title I Interim Report", Iowa Educational Information Center, University of Iowa, Iowa City, Iowa (Mimeo) P. 9.

[8] Coleman, op. cit. Table 3.24.2, P. 314.

$$TW_{1,j} = 0.45$$

grades 1, 2, 3, and 5,

$$TW_{1,j} = 0.60$$

grades 6;

$$TW_{1,j} = 0.90$$

for grades 8 and 10; and

$$TW_{2,j} = 0.45$$

for grades 1, 2, 3 and 5;

$$TW_{2,j} = 0.30$$

for grade 6;

$$TW_{2,j} = 0.00$$

for grades 8 and 10.

Figure IV-4 presents the weight for the Instructional Index and its components in tabular form.

SERVICE INDEX AND SERVICE EFFECTIVENESS INDEX PARAMETERS

The service weights are designed to reflect the relative importance of different compensatory service input variables, and to weight the relative importance of indices computed from these inputs when they are combined to create a service index. The weights requiring estimation for the Service Effectiveness Index estimate the impact of various impedance factors on a student's achievement.

Service Quality Weight estimates the impact of a program on achievement if the service offered is new ($SQW_{1,j}$). The "Hawthorne Effect" indicates that a new service affects the target population more noticeably than does an on-going program. This is probably more the result of the additional attention paid to the target population than a reflection of the quality of the program. On the other hand, it is certainly possible that a new program may be better fitted to a target

population than one that has remained unchanged over a number of years. Without additional research, these and other possibilities cannot be evaluated. SQW_1 is, therefore, set at 0.00

On the other hand, the Coleman Report indicates that no school variable has as great an effect as teacher quality[9], the effect of which is already quite small. SQW_2 is therefore set at 0.01, a level equal to the impact of teacher quality in lower grades, and half of the level of impact in higher grades.

Service Intensity Index weights are the parameters by which are set the impact on students of the ratios of paraprofessionals to students, space per student, and cost of budgeted materials per student. There is no evidence on the importance of space, so SIW_2 is set to 0.00. The other two weights, SQW_1 and SQW_3, are both set at 0.01 on the basis of the Coleman Report.[10]

Finally, the Service Weights, which are used in the function combining the different service industries, are determined by the method described in Figure IV.1 and in the text relating to that figure. They are:

$$SW_1 = 0.30$$

$$SW_2 = 0.60$$

$$SW_3 = 0.10$$

Impedance weights relate the student's level of achievement to the degree to which he is, by his background, disadvantaged. According to Coleman and others, these environmental factors account for by far the greatest part of variation in student achievement. These weights are therefore substantially greater than those which have been discussed up until this point. The first impedance factor measures disadvantages due to a parental income of $3000 or less

[9] Ibid., P. 22.

[10] Ibid., Table 3.24.2, P. 314-315.

per year. On the basis of the Coleman Report[11], this weight is estimated to be 0.04. The second weight (ZW_2) is set, on the same basis, at .12. Although no information is available as to the effect of a physical handicap on a student, it can be assumed that it hinders achievement. ZW_3 is, therefore, set at 0.01.

The fourth impedance weight is designed to reflect the effect on a student of family disruption. Both the Coleman Report[12] and Alan B. Wilson[13] find that this has no effect on the student's achievement. The weight is, therefore, set to 0.00.

ZW_5 and ZW_6 weight students' achievement lags by grade 12. Coleman finds that student body quality has an important effect on student achievement; calculations based on data in Equality of Educational Opportunity[14] indicate a setting of .04 for ZW_5. The impact of a student's own achievement lag is set at 0.02, half the other value, because while data on this is lacking, it must still be considered important.

Figure IV.5 presents the Service Weights in tabular form.

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[11] Ibid., pp. 298-302, especially Tables 3.22 1.3 and 3.22 1.6

[12] Ibid.; p. 302.

[13] Alan B. Wilson, "Educational Consequences of Segregations in a California Community," (Berkely, California: University of California Survey Research Center, 1966 Nineo), p. 26.

[14] Coleman, op cit., Table 3.23.1, p. 303

Figure IV. 1: A Hypothetical Example of Weight Summation.

INPUT WEIGHTS		INDEX WEIGHTS	
$TQW_{1,j}$	= .08		
$TQW_{2,j}$	= .04		
SUM	= .12	$TW_{1,j}$	= .60
$TIW_{1,j}$	= .01		
$TIW_{2,j}$	= .01		
$TIW_{3,j}$	= .03		
$TIW_{4,j}$	= .01		
SUM	= .06	$TW_{2,j}$	= .30
Instructional Duration		$TW_{3,j}$	= .10
Estimated Sum	= .02	SUM	= 1.00

Figure IV. 2: A Hypothetical Markov Matrix of Transition Probabilities from One Grade to the Next.

Performance in Subsequent Grade

		Fail-Fail Eng. Math.	Fail-Pass	Pass-Fail	Pass-Pass
Performance	Fail-Fail	.50	.20	.20	.10
in	Fail-Pass	.10	.25	.10	.55
Previous	Pass-Fail	.10	.10	.25	.55
Grade	Pass-Pass	.05	.05	.05	.85

Figure IV-3. MARKOV Matrix of Probability of Subsequent Grade Outcome, Given Previous Grade Outcome.

Transition	Previous Grade	FF	FP	PF	PP
1	FF	.60	.10	.10	.20
	FP	.15	.30	.10	.45
	PF	.10	.10	.30	.50
	PP	.05	.10	.10	.75
2	FF	.70	.08	.07	.15
	FP	.17	.40	.09	.34
	PF	.12	.09	.40	.39
	PP	.04	.08	.08	.80
3	FF	.78	.06	.05	.11
	FP	.19	.48	.08	.25
	PF	.14	.08	.48	.30
	PP	.03	.07	.06	.84
4	FF	.84	.04	.04	.08
	FP	.21	.54	.07	.18
	PF	.16	.07	.54	.23
	PP	.02	.06	.05	.87
5	FF	.88	.03	.03	.06
	FP	.23	.58	.06	.13
	PF	.18	.06	.58	.18
	PP	.02	.05	.05	.88
6	FF	.90	.03	.02	.05
	FP	.25	.60	.05	.10
	PF	.20	.05	.60	.15
	PP	.02	.05	.05	.88

FF - Fail English, Fail Math; FP - Fail English, Pass Math; PF - Pass English, Fail Math; PP - Pas English, Pass Math.

ure IV-4: Instruction Index Weights

Grade	Course	TQW_1 (RECEN)	TQW_2 (TCHEXP)	TIW_1 TCHRS	TIW_2 TEXTS	TIW_3 (DESKS)	TIW_4 (TCHBUD)	TW_1 (TCHQAL)	TW_2 (TCHITIN)	TW_3 (TCHDUR)
1	1	.00	.01	.00	.00	.00	.01	.45	.45	.10
	2	.00	.01	.00	.00	.00	.01	.45	.45	.10
2	1	.00	.01	.00	.00	.00	.01	.45	.45	.10
	2	.00	.01	.00	.00	.00	.01	.45	.45	.10
3	1	.00	.01	.00	.00	.00	.01	.45	.45	.10
	2	.00	.01	.00	.00	.00	.01	.45	.45	.10
5	1	.00	.01	.00	.00	.00	.01	.45	.45	.10
	2	.00	.01	.00	.00	.00	.01	.45	.45	.10
6	1	.00	.02	.00	.00	.00	.01	.60	.30	.10
	2	.00	.02	.00	.00	.00	.01	.60	.30	.10
8	1	.00	.02	.00	.00	.00	.00	.90	.00	.10
	2	.00	.02	.00	.00	.00	.00	.90	.00	.10
10	1	.00	.02	.00	.00	.00	.00	.90	.00	.10
	2	.00	.02	.00	.00	.00	.00	.90	.00	.10

Figure IV-5: Service and Service-Effectiveness Index Weights.

SQW	1	2				
	.00	.01				
SIW	1	2	3			
	.01	.00	.01			
SW	.30	.60	.10			
ZW	1	2	3	4	5	6
	.04	.12	.01	.00	.04	.02

CHAPTER V

ANALYSIS OF SAMPLE MODEL RUNS

INTRODUCTION:

One of the major problems in "software" development is that the final product is often in a form difficult to use. The OECE Model is designed to be used; it can, moreover, serve several purposes. The primary purpose for the development of the model was to provide assistance to administrators in allocating funds to education. The benefit of the Model's use is more than mechanical, as it also suggests some of the criteria by which educational programs should be measured. In addition, use of the model will provide information by which the model itself can be refined and improved.

The model must satisfy five major requirements if it is to be used:

1. The model must "work." When information is fed into a computer programmed with the model, the program must function correctly.
2. The model must use data which is easily obtained.
3. The model's output must be comprehensible.
4. The model's output must be accurate.
5. The model must be available to administrators.

In this chapter, the usability of the OECE Model will be examined in terms of the first four criteria. The availability of the model must of course be determined by the Office of Education. The other criteria are examined in this chapter by running the model for a sample school district, both before and after the implementation of compensatory education programs. Since performance of the school district and its compensatory education programs have already been evaluated, the validity of the model can be tested with some accuracy.

USING THE MODEL: A SAMPLE CASE, THE DATA BASE

Data for the OECE Model test run was obtained for a school district serving a city with a population of approximately 140,000. Runs of the model were made for each of two different assumptions, a baseline run and another which examined changes due to compensatory education. The first assumption

was based on a school district's own Markov matrix of probable transitions of students from one grade to another. The second used the generalized matrix developed for the model (see Chapter IV). Certain data, (the student/desk ratio, for example) was unavailable. In these cases, either the conditions were assumed to be totally satisfactory, or the condition was assumed to be average.

The grade-specific data base for the sample case is shown in Table V-1 for both baseline and compensatory education runs. Much of the data needed for the model, although it was probably available in the school district, was not readily accessible. Moreover, most data was not available by course, was entered for both English and Mathematics courses.

Other OECE Model input files require a variety of types of information which are not used in indices, and therefore do not require manipulation before insertion into computer input files. Included among these is DIS, the percentage of students with a given disadvantage factor (see Table V-2). This information is based on teachers' evaluations of their classes. Other needed information includes the number of grade levels with test scores available (7) the number of student types (4), the initial grade in which compensatory education programs were implemented (grade 2), and national test norms in grade level equivalents for the month in each grade in which the test was administered by the schools.

Several observations should be made on these pieces of information. First, test scores were not from the same tests for all grades, but all tests were converted into grade level equivalents. Moreover, some tests did not test Mathematics and English achievement separately; it was assumed in such cases that achievement scores were equivalent for the two categories. Second, achievement data was only available by school. Schools were predominantly Negro, predominantly Mexican-American, or predominantly white. Data from the predominantly Negro schools was used for the first student type category (i.e., "Negro, income less than $3000"); data from Mexican-American schools was used for the second student type; and data for predominantly white schools was used for the fourth student type category. This system of assigning school data to student type category was used throughout the other files, so that "student type" actually refers to school type.

Other input files which require school system data are presented in Tables V-3 through V-7. Several points should be noted. The number of students of each type in the grade level before the compensatory education program was implemented (i.e., grade 1) was set arbitrarily at 1000, so that, the effect of programs on an equivalent number of students could be measured for each school type. The initial grade level achievement scores are the same for English and Mathematics courses, as the achievement test given at grade 1 does not differentiate between the two fields. The same is true for rates of achievement and the initial achievement distribution of students. In addition, it should be remembered that passing and failing are defined as achievement above and below, respectively, the national average. Finally, although there are two courses in grades 1, 2, 3 and 10, achievement tests do not distinguish between them.

Additional data required by the model concerns the characteristics of the compensatory services offered. This information, as presented in Table V-8, is relatively complete and self-explanatory.

ADAPTATION OF THE DATA BASE FOR MODEL USE

The data base which was presented above has a number of deficiencies. Some of these shortcomings can be explained by a lack of direct access to sources of data, and would not occur during normal use. Others will no doubt be common problems when the model is actually used. All these deficiencies are surmountable. Indeed, in using a model which is to be applied to many different situations, as is this one, the adaptation of data is a necessary task, particularly so because all input indices must vary between 0 and 1.

This task is two-fold: The available data must first be converted into indices which can be used in the model, and the indices must be estimated where data is unavailable.

For the first of these procedures, a method of converting data into indices must be decided upon and then used consistently. The user is free to adapt the available data to the model by any method he considers legitimate. A brief description of the methods used for each of the indices in the sample case will give some idea of the range of methods which can be used. The indices derived by these methods are presented in Table V-9.

The TCHEXP (Teacher Experience) Index was designed to reflect the fraction of the teacher population with less than two years of teaching experience, as this was thought a means of differentiating between experienced and inexperienced teachers. By using the mean for years of teaching experience, the standard deviation from that mean, and the number of teachers, this figure was computed. A user of more accurate information would not have to resort to these methods.

To derive the TCHRS (Teacher/Pupil Ratio), a range of ratios from extremely poor (1/40) to optimum (1/10) was established. The index was then computed by the following method:

$$\text{TCHRS} = 1 - \frac{(\text{actual number of pupils per teacher} - 10)}{40-10}$$

so that a school with one teacher to every ten pupils would have the maximum index value, 1.0.

The Instructional Budget Index was determined by setting the baseline value for which data was unavailable to equal the position of the state which district is in among all states in expenditures per pupil. Thus,

$$\text{TCHBUD}_{\text{baseline}} = \frac{\text{expenditure/pupil in state with district} - \text{expenditure/pupil in lowest state}}{\text{expenditure/pupil in highest state} - \text{expenditure/pupil in lowest state}}$$

For the compensatory education run, the amount by which the instructional budget would increase the district's per pupil expenditure was calculated. In this way a new expenditure/pupil ratio for the district was determined and substituted for the expenditure/pupil ratio based upon the state which contains the district.

Service variables were set to 0 for the baseline run. For the non-baseline run, indices were computed only for Negro and Mexican-American student types, since the service programs were only implemented in those schools. Thus, service variables for whites (student type 4) were set to 0 for all runs.

Service data which required manipulation into service indices included: the paraprofessional/pupil ratio, the space available for the service, and the service budget. These indices were computed by various methods.

The optimum number for paraprofessionals necessary for adequate performance of the service was estimated, and the actual number used for the service was divided by this number to yield PARA.

Optimum amount of space needed for performance of these services was likewise estimated, and actual space used divided by optimum space needed, to product SPACE.

In order to estimate SBUDGT, the budget cost for the service was broken down into the cost per paraprofessional, the cost per unit of space, and the cost per student aided by the service. An optimum budget was calculated using this data, the optimum ratios employed in the computation of PARA and SPACE, and the number of students who needed the services. The actual budget figure was then divided by the optimum figure to produce SBUDGT.

For a substantial number of the indices needed for model operation, data was not readily available. In these cases, one of two assumptions was made. Either it was assumed that the functions specified by the variable were being performed very well, in which case the index was set at .99 or 1, or it was assumed that the system was performing with average adequacy, and the value was therefore set at .50. The only case where neither of these assumptions was made was in the estimation of TEXTS, where the index value was set at .90 for all cases. It is important to note here that as long as an index is made constant for all cases, its effect on individual indices is constant, and the value at which it is set is of no great consequence.

The first assumption, of very good performance, was made for recency of curriculum material, desks/pupil, instructional hours/day, days/week, weeks/year, while the second assumption (of average adequacy) was made for service hours/day, days/week and weeks/year. The input index values for instructional indices are listed in Table V-9, and those for service indices in Table V-10.

ADAPTATION OF THE MODEL FOR USE WITH THE DATA

The OECE Model does not require any modification to be run with input indices as computed above. If, however, the user is aware of the importance of certain factors not heavily weighted by the model, or if he

wants to test a hypothetical situation in which a certain factor is given a disproportionate weight, the modification procedure, as outlined in Appendix A, is a relatively simple one. For the present sample run, it was decided to leave all weights at their model settings for both baseline and compensatory education runs.

Data available from the school district being studied made it possible to alter the Markov matrix of transitional probability of achievements to reflect actual transition occurences within the school district (see Table V-11), and so a second model run was performed. Thus, in all, four different model runs were made: 1) baseline with generalized Markov matrix; 2) compensatory education with generalized Markov matrix; 3) baseline with the school district-specific Markov matrix; 4) compensatory education with the school-district-specific matrix.

MODEL OUTPUT

MEANING OF OUTPUT ITEM

Any run of the OECE Model produces one page of output for each type of student. Table V-12 contains a typical page of model output. Information is of several types. First, the number of truants and dropouts, and the achievement scores in English and Mathematics for all students are predicted for each grade level beyond the initial grade level. Thus, in the sample case, these data are presented for six grades. "Equality of Educational Opportunity" is predicted for grades for which output is requested in the model. Finally, a relative measure of potential and expected lifetime earnings is reported for dropouts at various grade levels and for graduates going into each of three activities. Mean potential and expected lifetime earnings are also reported for the student types. Each of these measures requires some brief explanation. Grade is a real number rather than an integer, so that the time year of testing can be taken into account. The achievement scores are for all tests given, and are converted into grade level equivalents. Truants describe the rate of truancy, an effect of achievement lag, as was discussed in earlier chapters. Dropouts is also based on achievement lag. "Equality of Education Opportunity" is based on Coleman's concept of the relationship between school achievement and

socio-economic background, and is a function of the difference in expected achievement for different student types. Higher levels of the index denote greater equality of educational opportunity. Finally, lifetime earnings are projected for several levels of educational achievement and for graduates. Potential lifetime earnings denotes the earning possible if full employment is assumed while expected lifetime earnings is a measure which takes the probability of unemployment into account.

INTERPRETATION OF RUN RESULTS

The output measure discussed are not absolute: They do not predict the absolute changes, as for example, in achievement or earnings, but are computed such so that figures are comparable across a given data base, both among student types, and for a given student type from baseline to compensatory education situations. The simplest (and probably most legitimate) interpretation of model output involves the latter type of activity, in which comparisons are made for each type of student. The former method, of comparing results across the student types, can only be initiated after differences within each type are determined, since comparison of absolute levels does not have a great deal of significance within the model.

USING THE GENERALIZED MARKOV MATRIX

Tables V-12 through V-17 present model output for the baseline and compensatory education runs of the OECE Model. Output for "whites -- less than $3000" is not included since student type was used to represent school type, and there were no schools of this type.

A comparison of baseline and compensatory education output indicates that overall changes are minimal. There are slight (.01) decreases at some grade levels in achievements for the Negro and Mexican-American schools, and increases of the same magnitude for whites in certain grades. The absolute level of achievement becomes progressively higher than the Negro level for Mexican American and white schools. Truancy and dropout rates do not change at all, while equality of educational opportunity decreases slightly for Negroes in English, and for Mexican-Americans in Mathematics. In addition, there is a small decrease in potential and expected lifetime

earnings for Negroes and Mexican-Americans, and a small increase for whites. If the model, its weighting and Markov matrix and its inputs are assumed to reflect accurately the school district for which the model is being run, several conclusions are in order. First, the rate of achievement differs in schools which are predominantly Negro, Mexican-American, and white. Negroes show a lower level of achievement, while whites have the higher grades. Secondly, the effect of the compensatory education program on the school system is minimal. All changes are extremely small. Thirdly, these minimal effects are slightly positive for whites (who already enjoy equality of educational opportunity), and slightly negative for those who most need improvement in education, i. e., Negroes and Mexican-Americans. The validity of these conclusions will be examined after the results of the second series of the model runs are described.

RUNS USING THE SCHOOL DISTRICT-SPECIFIC MARKOV MATRIX

The second series of model runs utilized a Markov Matrix which reflected as accurately as possible the actual transitional probabilities of passing and failing in the school district for which the model was being run. Model output for these runs in included in Table V-18 through V-23. On the whole, these runs showed a stronger positive effect of compensatory education programs in the disadvantaged populations.

Achievement is a case in point. Although achievement declined somewhat (for "Negroes-less than $3000,") from the baseline to the compensatory education conditions for grades 3, 5, and 6, there was an increase for this group in grades 8 and 10. By grade 10, there was a concommitant increase in equality of educational opportunity. The pattern is quite similar for Mexican-Americans and for "Negroes-more than $3000." These schools showed a decrease in achievement in grades 2, 3, and 5, and a substantial increase in the later grades. As was the case with Negroes, equality of educational opportunity was increased. Finally, whites, unlike the other two groups, showed practically no changes in achievement from the baseline to the compensatory education situation.

If this second series of model run is taken as an accurate and undistorted reflection of the system's actual operation, conclusions would

differ significantly from those based on the first run. 1) The differential between Negro and the Mexican-American achievement is substantially smaller in most baseline and compensatory education cases than when the generalized Markov matrix was used; 2) Moreover, the differential between Negro and Mexican-American achievement rates and those for whites is not as great as in the first series of model runs. 3) The overall effect of compensatory education programs seems, moreover, to be significant. Although the effect in earlier grades is somewhat negative, there is a clear increase in achievement by Negroes and Mexican-Americans in the later grades.

COMPARISON OF THE RUNS, THEIR PREDICTIONS AND KNOWN RESULTS

Conclusions drawn from the two series of runs differ because of the differences between the Markov matrices. Since no other input was changes, all differences in results must stem from this difference. The impact of the Markov matrix may be summarized briefly: the level of achievement for any grade, a course and group, is in part dependent upon the Markov matrix, and changes from the baseline to the compensatory education situation are in part functions of the matrix used.

It is beyond the scope of this chapter to deal with the mathematical mechanics of a Markov matrix. Nonetheless, it is important to understand why different matrices has such a strong influence on model results. The matrix takes students at one grade level with specific pass-fail characteristics and, according to the probabilities for students in that previous condition, assign an appropriate number of students from that condition to each of the possible conditions at the next grade level. When this is done for successive grade transitions, there is a possibility of progressive movement into certain categories. This drift is a function of both matrix design and original achievement (i.e., pass-fail) distribution of students.

Differing results in the two model runs may be explained in the following manner: baseline distributions of student achievement are influenced by the two matrices in different ways producing certain "drift" patterns. Specifically, the initial distribution of white students produces a drift to excessively high achievement compared to other groups when the generalized Markov matrix is used for the baseline run. This matrix is virtually

unresponsive to changes in achievement distribution caused by implementation of compensatory education programs. On the other hand, the district-specific matrix more accurately reflects the baseline achievement distribution of each type of student at successive grade level; the drift is one that accurately reflects trends of student populations. This may be seen from the comparison of the district-specific Markov model output in Tables V-18, V-20 and V-22 with actual achievement rates for students in the district (in Table V-24). The district-specific Markov matrix is also far more responsive to changes in student achievement distribution which result from compensatory education program implementation. The Markov matrix is shown to be important because of inherent characteristics which have strong effects on model results. The inaccurate drift of the matrix seems to vary along two dimensions: 1) inaccurate drift in reflecting baseline achievement levels, and 2) inaccurate drift in responding to changes in achievement distributions. The two Markov matrices used in this study are overly-responsive, the generalized matrix in predicting baseline achievement, and the district-specific matrix in reflecting shifts in achievement because of compensatory education programs. Matrices could similarly be under-responsive.

The effect of compensatory education programs projected by the model with a district-specific Markov matrix has an over responsive drift, as shown when the model projections are compared to actual program performance.

An evaluation of effectiveness of the compensatory programs within the district demonstrates that achievement rates in all district schools are declining either because of an influx of families whose children have lower achievement rates, or because of some internal process. However, schools with compensatory education programs were found to have achievement rates declining at a lower rate than the non-compensatory education schools (see Table V-24). The effect seems minimal and only significant by the third grade. Moreover, an inhibited rate of decline rather than an actual increase distinguishes the compensatory education schools from the other schools.

The only shortcoming of the district-specific matrix model seems to be that it predicts an effect greater by a substantial margin than that which actually occurs. There are two possible explanations for this occurrence.

It may be that the district-specific Markov matrix is too responsive to changes in student achievement distributions. If this is the case, the matrix can be stiffened or made more stable. It is also possible, although not likely, that the model places too great an emphasis on the impact of compensatory education. Further research and extensive use of the model will be necessary before these alternative explanations can be evaluated, whichever is the case, it is essential to keep in mind the adaptability of the model, which can easily withstand changes resulting from either conclusion. Furthermore, as was emphasized earlier, the OECE Model was designed to show relative changes in effect rather than the absolute magnitude of these effects.

SUMMARY AND CONCLUSIONS

This chapter has focused on the importance of the OECE Model as defined by five criteria:

1) the model "works,"
2) input requirements are feasible,
3) output is interpretable,
4) output interpretations have validity
5) potential users have access to the model.

The last criterion cannot be evaluated at present. The other four have been tested with actual data. From results at these tests, several comments may be made concerning the model's effectiveness.

First, it is evident that the model "works" in the very concrete programming sense. When it is run with input requirements satisfied, it produces output accurately and efficiently.

Feasibility of input requirements also seems to be satisfied criterion. Although not all data asked for by the model was obtained, inability to acquire this data was resulted primarily from lack of access to data sources, a problem which would not occur for users closer to data sources. Moreover, where data was unavailable, it was possible to make estimates which did not effect model results. Therefore, input requirements are feasible because even if only knowledge of one variable is available, dummy data may be substituted for missing variables, and the model will produce predictions

based on one real variable.

A second phase of input to the model requires construction of indices rangeing from 0.0 to 1.0 for each of the variables. Although this job requires some imagination on the user's part, it is a task which can be accomplished in any of a variety of ways, depending upon the user's need for and/or ability to use sophisticated methods.

The third criterion is output interpretability. Since two sets of output were produces, this characteristic is demonstrated. Each set had interpretations which seemed to logically follow from comparison of baseline to non-baseline output and comparison of these changes for various student types.

The interpretations which resulted from the two sets of model runs differed substantially. These differences raised the question of model validity. It was shown that the conflicting interpretations resulted from the use of Markov matrices which possessed different "drift"qualities. A comparison of interpretations with actual results of compensatory education programs in the school district indicated that when the model was run using a district-specific Markov matrix, the results were fairly similar to actual results. Differences were quantitative, not qualitative.

Quantitative inaccuracies are thought to result from one of two characteristics. A Markov matrix may be so specific for achievement patterns in a particular district that achievement distribution variance results in drift patterns. In addition, weighting of model parameters may suggest a greater influence for compensatory education programs than actually exists. Whichever of this occurs, it is evident (as discussed in Chapter IV) that the validity of a model is dependent not only on the algorithms which relate its terms, but on the weighting of terms and the accuracy of inputs. Therefore, if the model is to maintain and increase its validity and relevance, its weights must be continually adjusted to reflect applications and emerging changes in the strength of relationships. This is especially important if the model is made available to users who report their methods and findings.

TABLE V-1: The Sample Run Instructional Data Base

Grades	Mathematics, Science and Related Courses				English, Writing, History, and Related Courses			
	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12
A. BASELINE (1964-1965) DATA								
Mean textbook publication date	Not available				Not available			
Teacher Experience (years)	6.7	6.7	6.4	8.1	6.7	6.7	6.4	8.1
Teacher/Pupil Ratio	36	36	25	25	36	36	25	25
Text/Pupil Ratio	Not available				Not available			
Desks/Pupil Ratio	Not available				Not available			
Instructional Budget (X $1000)	Not available				Not available			
Mean class time	Not available				Not available			
Hours	"				"			
Days	"				"			
Weeks	"				"			
B. TITLE I (1967-1968) DATA								
Mean textbook publication date	Not available				Not available			
Teacher Experience (years)	6.1	6.1	6.4	7.9	6.1	6.1	6.4	7.9
Teacher/Pupil Ratio	27	27	23	22	27	27	23	22
Text/Pupil Ratio	Not available				Not available			
Desks/Pupil Ratio	Not available				Not available			
Instructional Budget (X $1000)*	0	0	31	70	80	0	31	70
Mean class time	Not available				Not available			
Hours	"				"			
Days	"				"			
Weeks	"				"			

es represent additional instructional expenditures.

TABLE V-2: DIS File, Percentage of Students, by Type, with Disadvantages for Sample Case

STUDENT TYPE DISADVANTAGES	Negro Less than $3000 (Negro)	Negro More than $3000 (Mexican-American)	White Less than $3000 (White)	White More than $3000 (White)
Income less than $3000	100%	0%	100%	0%
Parents' education elementary or less	41%	50%	50%	20%
Student has physical handicap	27%	20%	20%	15%
Student's family is disrupted	45%	35%	30%	20%
Achievement Lag of Fellow Students	60%	50%	40%	20%
Achievement Lag of Individual Student	60%	50%	40%	20%

TABLE V-3: File LASTI--Number of Students of Each Student

STUDENT	TYPE	NUMBER
	1	1000
	2	1000
	3	1000
	4	1000

TABLE V-4: File INGLEV--Initial Grade Level Achievement Scores

STUDENT	ACHIEVEMENT	
	English	Mathematics
1	1.14	1.14
2	1.30	1.30
3	1.70	1.70
4	1.90	1.90

TABLE V-5: File STATIN--Rates of Achievement

STUDENT	ACHIEVEMENT	
	English	Mathematics
1	.30	.30
2	.35	.35
3	.45	.45
4	.50	.50

TABLE V-6: File PPINIT--Initial Achievement Distribution of Students

STUDENT TYPE	Fail	Pass
1	90%	10%
2	83%	17%
3	50%	50%
4	50%	50%

TABLE V-7: File NOCORS--Number of courses by Grade

GRADE	Number of Courses
1	2
2	2
3	2
5	2
6	2
8	2
10	2

TABLE V-8: Compensatory Services Data (Title I Run)

Data	Counseling	Reading Centers	Study Trips	Health Services	School-Home Liaison	Electrical Teacher Aides
Grade in which service offered	10-12	1-6	1-12	1-12	10-12	1-12
Service is new	yes	yes	yes	yes	yes	yes
Service is free	yes	yes	yes	yes	yes	yes
Paraprofessional w/service	5	2	0	5	2	23
Space used for service	n/a	5 rooms	----	----	----	----
Service budget (x $1000)	78	57	83	40	12	56
Disadvantages Service is designed to compensate for*	2, 5	5, 6	1, 2, 5	1, 3	2, 4	0
Amount of time spent by participant in service						
Hours	Not available					
Days	Not available					
Weeks	Not available					

*CODE:
1 = Family poverty
2 = Parents' low level of education
3 = Physical Handicaps
4 = Broken family situation
5 = Whole class achievement lag
6 = Individual achievement lag
0 = none of these

TABLE V-9: The Sample Run Instructional Indices

	Mathematics, Science and Related Courses				English, Writing, History and Related Courses			
GRADES	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12
A. BASELINE (1964-1965) INDICES								
RECEN	1	1	1	1	1	1	1	1
TCHEXP	1	1	.98	.98	1	1	.98	.98
TEXTS	.90	.90	.90	.90	.90	.90	.90	.90
DESKS	.99	.99	.99	.99	.99	.99	.99	.99
TCHBUD	.48	.48	.48	.48	.48	.48	.48	.48
CTHRS	.99	.99	.99	.99	.99	.99	.99	.99
TCHDYS	.99	.99	.99	.99	.99	.99	.99	.99
TCHWKS	.99	.99	.99	.99	.99	.99	.99	.99
B. TITLE I (1967-1968) INDICES								
RECEN	1	1	1	1	1	1	1	1
TCHEXP	1	1	1	.98	1	1	1	.98
TEXTS	.90	.90	.90	.90	.90	.90	.90	.90
DESKS	.99	.99	.99	.99	.99	.99	.99	.99
TCHBUD	.48	.48	.50	.51	.50	.48	.50	.51
CTHRS	.99	.99	.99	.99	.99	.99	.99	.99
TCHDYS	.99	.99	.99	.99	.99	.99	.99	.99
TCHWKS	.99	.99	.99	.99	.99	.99	.99	.99
TCHRS	.13	.13	.50	.50	.13	.13	.50	.50
TCHRS	.43	.43	.57	.60	.43	.43	.57	.60

TABLE V-10: The Sample Run Service Indices (Title I Run)

	Service Counseling	Reading Centers	Study Trips	Health Services	School-Home Liaison	Clerical Teacher Aides
NEW	1	1	1	1	1	1
FREE	1	1	1	1	1	1
PARA	.55	.20	1.00	.50	.50	.10
SPACE	1.00	.50	1.00	1.00	1.00	1.00
SBUDGT	.60	.33	.75	.50	.50	.10
SHOURS	.50	.50	.50	.50	.50	.50
SDAYS	.50	.50	.50	.50	.50	.50
SWEEKS	.50	.50	.50	.50	.50	.50

TABLE V-11: District-Specific Markov Matrix of Transitional Achievement Probabilities

Transition from Grade	Previous Performance	Subsequent Performance			
		Fail, Fail	Fail, Pass	Pass, Fail	Pass, Pass
1	fail, fail	.80	.00	.00	.20
	fail, pass	.00	.00	.00	.00
	pass, fail	.00	.00	.00	.00
	pass, pass	.40	.00	.00	.60
2	fail, fail	.80	.00	.00	.20
	fail, pass	.00	.00	.00	.00
	pass, fail	.00	.00	.00	.00
	pass, pass	.15	.00	.00	.80
3	fail, fail	.60	.00	.00	.40
	fail, pass	.00	.00	.00	.00
	pass, fail	.00	.00	.00	.00
	pass, pass	.05	.00	.00	.95
5	fail, fail	.60	.00	.00	.40
	fail, pass	.91	.06	.01	.02
	pass, fail	.88	.02	.07	.03
	pass, pass	.30	.00	.00	.70
6	fail, fail	.95	.005	.005	.04
	fail, pass	.80	.03	.00	.17
	pass, fail	.65	.01	.04	.30
	pass, pass	.20	.00	.00	.80
8	fail, fail	.80	.00	.00	.20
	fail, pass	.68	.00	.00	.32
	pass, fail	.41	.00	.00	.59
	pass, pass	.10	.00	.00	.90

TABLE V-12: Baseline Output Using Generalized MARKOV Matrix

NEGROES--LESS THAN $3000

GRADE	ACHIEVEMENT ENGLISH	ACHIEVEMENT MATH	TRUANTS	DROPOUTS
2.9	1.6	1.58	12	0
3.9	2.5	2.46	12	0
5.2	3.9	3.81	11	0
6.2	5.0	4.92	12	0
8.2	7.3	7.13	8	0
10.2	9.4	9.24	0	0

EQUALITY OF EDUCATIONAL OPPORTUNITY

GRADE = 10.0 ENGLISH = .68 MATH = .67

	NUMBER	POTENTIAL LIFETIME EARNINGS	EXPECTED LIFETIME EARNINGS
GRADE 6 DROPOUTS	0	29671	21726
GRADE 10 DROPOUTS	0	64887	48844
GRADE 12 DROPOUTS	34	70652	54638
VOCATIONAL	400	70947	62175
COMMERCIAL	491	61861	54212
ACADEMIC	73	94886	89484
TOTAL	1000	68195	59982

TABLE V-13: Compensatory Education Output Using Generalized MARKOV Matrix

NEGROES--LESS THAN $3000

GRADE	ACHIEVEMENT ENGLISH	ACHIEVEMENT MATH	TRUANTS	DROPOUTS
2.9	1.6	1.58	12	0
3.9	2.5	2.45	12	0
5.2	3.9	3.81	11	0
6.2	5.0	4.91	12	0
8.2	7.2	7.12	8	0
10.2	9.4	9.23	0	0

EQUALITY OF EDUCATIONAL OPPORTUNITY

GRADE = 10.0 ENGLISH = .68 MATH = .67

	NUMBER	POTENTIAL LIFETIME EARNINGS	EXPECTED LIFETIME EARNINGS
GRADE 6 DROPOUTS	0	29671	21726
GRADE 10 DROPOUTS	0	64817	48792
GRADE 12 DROPOUTS	34	70584	54585
VOCATIONAL	400	70871	62109
COMMERCIAL	491	61795	54154
ACADEMIC	73	94874	89471
TOTAL	1000	68129	59924

TABLE V-14: Baseline Output Using Generalized MARKOV Matrix

NEGROES--MORE THAN $3000

GRADE	ACHIEVEMENT ENGLISH	ACHIEVEMENT MATH	TRUANTS	DROPOUTS
2.9	1.9	1.90	11	0
3.9	2.9	2.87	11	0
5.2	4.4	4.31	10	0
6.2	5.6	5.48	10	0
8.2	7.9	7.78	6	0
10.2	10.1	9.97	0	0

EQUALITY OF EDUCATIONAL OPPORTUNITY

GRADE = 10.0 ENGLISH = .73 MATH = .73

	NUMBER	POTENTIAL LIFETIME EARNINGS	EXPECTED LIFETIME EARNINGS
GRADE 6 DROPOUTS	0	32733	23963
GRADE 10 DROPOUTS	0	69964	52666
GRADE 12 DROPOUTS	30	75645	58499
VOCATIONAL	302	76437	67031
COMMERCIAL	516	66692	58446
ACADEMIC	150	98225	92939
TOTAL	1000	74643	66212

TABLE V-15: Compensatory Education Output Using Generalized MARKOV Matrix

NEGROES--MORE THAN $3000

GRADE	ACHIEVEMENT ENGLISH	ACHIEVEMENT MATH	TRUANTS	DROPOUTS
2.9	1.9	1.90	11	0
3.9	2.9	2.86	11	0
5.2	4.4	4.31	10	0
6.2	5.6	5.47	10	0
8.2	7.9	7.78	6	0
10.2	10.1	9.96	0	0

EQUALITY OF EDUCATIONAL OPPORTUNITY

GRADE = 10.0 ENGLISH = .73 MATH = .72

	NUMBER	POTENTIAL LIFETIME EARNINGS	EXPECTED LIFETIME EARNINGS
GRADE 6 DROPOUTS	0	32733	23968
GRADE 10 DROPOUTS	0	69929	52640
GRADE 12 DROPOUTS	30	75611	58473
VOCATIONAL	302	76457	67004
COMMERCIAL	516	66666	58422
ACADEMIC	150	98218	92931
TOTAL	1000	74615	66187

TABLE V-16: Baseline Output Using Generalized MARKOV Matrix

WHITES --MORE THAN $3000

GRADE	ACHIEVEMENT ENGLISH	ACHIEVEMENT MATH	TRUANTS	DROPOUTS
2.9	3.2	3.18	7	0
3.9	4.6	4.61	6	0
5.2	6.6	6.50	3	0
6.2	8.0	7.93	2	0
8.2	10.8	10.69	0	0
10.2	13.4	13.26	0	0

EQUALITY OF EDUCATIONAL OPPORTUNITY

GRADE = 10.0 ENGLISH = 1.00 MATH = 1.00

	NUMBER	POTENTIAL LIFETIME EARNINGS	EXPECTED LIFETIME EARNINGS
GRADE 6 DROPOUTS	0	57004	56560
GRADE 10 DROPOUTS	0	114769	113938
GRADE 12 DROPOUTS	12	121323	120516
VOCATIONAL	177	125414	124959
COMMERCIAL	460	109354	108955
ACADEMIC	335	134657	134477
TOTAL	1000	119238	118903

TABLE V-17: Compensatory Education Output Using Generalized MARKOV Matrix

WHITES --MORE THAN $3000

GRADE	ACHIEVEMENT ENGLISH	ACHIEVEMENT MATH	TRUANTS	DROPOUTS
2.9	3.2	3.18	7	0
3.9	4.6	4.61	6	0
5.2	6.6	6.50	3	0
6.2	8.0	7.94	2	0
8.2	10.8	10.70	0	0
10.2	13.4	13.27	0	0

EQUALITY OF EDUCATIONAL OPPORTUNITY

GRADE = 10.0 ENGLISH = 1.00 MATH = 1.00

	NUMBER	POTENTIAL LIFETIME EARNINGS	EXPECTED LIFETIME EARNINGS
GRADE 6 DROPOUTS	0	57004	56560
GRADE 10 DROPOUTS	0	114355	114024
GRADE 12 DROPOUTS	12	121407	120600
VOCATIONAL	177	125508	125053
COMMERCIAL	460	109435	109036
ACADEMIC	335	134669	134490
TOTAL	1000	119281	118946

TABLE V-18: Baseline Output Using District-Specific MARKOV Matrix

NEGROES--LESS THAN $3000

GRADE	ACHIEVEMENT ENGLISH	ACHIEVEMENT MATH	TRUANTS	DROPOUTS
2	1.1	1.08	14	0
3	1.5	1.54	15	0
5	3.6	3.57	12	0
6	4.7	4.69	13	0
8	6.2	6.26	11	0
10	8.2	8.26	74	1

EQUALITY OF EDUCATIONAL OPPORTUNITY

GRADE = 2	ENGLISH = .00	MATH = .00
GRADE = 3	ENGLISH = 1.09	MATH = 1.09
GRADE = 5	ENGLISH = .12	MATH = .12
GRADE = 6	ENGLISH = -.01	MATH = -.01
GRADE = 8	ENGLISH = -.11	MATH = -.11
GRADE = 10	ENGLISH = -.15	MATH = -.15

	NUMBER	POTENTIAL LIFETIME EARNINGS	EXPECTED LIFETIME EARNINGS
GRADE 6 DROPOUTS	0	27937	20492
GRADE 10 DROPOUTS	1	57411	43216
GRADE 12 DROPOUTS	39	63299	48952
VOCATIONAL	426	62644	54899
COMMERCIAL	463	54621	47868
ACADEMIC	67	93702	88259
TOTAL	1000	60907	53529

UNEMPLOYMENT RATE = .040

TABLE V-19: Compensatory Education Output Using District-Specific MARKOV Matrix

NEGROES--LESS THAN $3000

GRADE	ACHIEVEMENT ENGLISH	ACHIEVEMENT MATH	TRUANTS	DROPOUTS
2.9	1.1	1.08	14	0
3.9	1.5	1.48	16	0
5.2	3.2	3.19	13	0
6.2	4.5	4.46	13	0
8.2	6.3	6.28	11	0
10.2	8.5	8.51	51	0

EQUALITY OF EDUCATIONAL OPPORTUNITY

GRADE = 10.0 ENGLISH = -.11 MATH = -.11

	NUMBER	POTENTIAL LIFETIME EARNINGS	EXPECTED LIFETIME EARNINGS
GRADE 6 DROPOUTS	0	25660	18788
GRADE 10 DROPOUTS	0	59134	44551
GRADE 12 DROPOUTS	38	65044	50301
VOCATIONAL	421	64587	56602
COMMERCIAL	470	56316	49352
ACADEMIC	68	93954	88519
TOTAL	1000	62637	55063

TABLE V-20: Baseline Output Using District-Specific MARKOV Matrix

NEGROES--MORE THAN $3000

GRADE	ACHIEVEMENT ENGLISH	ACHIEVEMENT MATH	TRUANTS	DROPOUTS
2	1.5	1.49	12	0
3	1.9	1.94	14	0
5	3.7	3.71	12	0
6	4.8	4.82	12	0
8	6.4	6.36	11	0
10	8.3	8.29	70	1

EQUALITY OF EDUCATIONAL OPPORTUNITY

GRADE	ENGLISH	MATH
GRADE = 2	ENGLISH = .00	MATH = .00
GRADE = 3	ENGLISH = 2.19	MATH = 2.17
GRADE = 5	ENGLISH = .26	MATH = .26
GRADE = 6	ENGLISH = .09	MATH = .09
GRADE = 8	ENGLISH = -.04	MATH = -.04
GRADE = 10	ENGLISH = -.11	MATH = -.11

	NUMBER	POTENTIAL LIFETIME EARNINGS	EXPECTED LIFETIME EARNINGS
GRADE 6 DROPOUTS	0	28844	21120
GRADE 10 DROPOUTS	1	57654	43400
GRADE 12 DROPOUTS	39	63539	49137
VOCATIONAL	364	62917	55138
COMMERCIAL	493	54860	48076
ACADEMIC	100	95151	90068
TOTAL	1000	62098	54802

UNEMPLOYMENT RATE = .040

TABLE V-21: Compensatory Education Output Using District-Specific MARKOV Matrix

NEGROES--MORE THAN $3000

GRADE	ACHIEVEMENT ENGLISH	ACHIEVEMENT MATH	TRUANTS	DROPOUTS
2.9	1.4	1.37	13	0
3.9	1.8	1.84	14	0
5.2	3.6	3.60	12	0
6.2	4.9	4.87	12	0
8.2	6.7	6.70	9	0
10.2	8.9	8.93	12	0

EQUALITY OF EDUCATIONAL OPPORTUNITY

GRADE = 10.0 ENGLISH = -.03 MATH = -.03

	NUMBER	POTENTIAL LIFETIME EARNINGS	EXPECTED LIFETIME EARNINGS
GRADE 6 DROPOUTS	0	28171	20627
GRADE 10 DROPOUTS	0	62105	46750
GRADE 12 DROPOUTS	36	67916	52522
VOCATIONAL	343	67774	59395
COMMERCIAL	504	59095	51788
ACADEMIC	115	96317	90964
TOTAL	1000	66636	58903

TABLE V-22: Baseline Output Using District-Specific MARKOV Matrix

WHITES --MORE THAN $3000

GRADE	ACHIEVEMENT ENGLISH	ACHIEVEMENT MATH	TRUANTS	DROPOUTS
2	2.5	2.51	9	0
3	3.3	3.29	10	0
5	5.3	5.27	7	0
6	6.6	6.58	7	0
8	8.4	8.44	4	0
10	10.7	10.70	0	0

EQUALITY OF EDUCATIONAL OPPORTUNITY

GRADE = 2	ENGLISH = .00	MATH = .00
GRADE = 3	ENGLISH = 3.22	MATH = 3.22
GRADE = 5	ENGLISH = .91	MATH = .91
GRADE = 6	ENGLISH = .62	MATH = .62
GRADE = 8	ENGLISH = .42	MATH = .42
GRADE = 10	ENGLISH = .31	MATH = .31

	NUMBER	POTENTIAL LIFETIME EARNINGS	EXPECTED LIFETIME EARNINGS
GRADE 6 DROPOUTS	0	47466	47096
GRADE 10 DROPOUTS	0	91987	91321
GRADE 12 DROPOUTS	26	98918	98260
VOCATIONAL	193	100384	100020
COMMERCIAL	480	87529	87209
ACADEMIC	299	129325	129140
TOTAL	1000	102757	102460

UNEMPLOYMENT RATE = .040

TABLE V-23: Compensatory Education Output Using District-Specific MARKOV Matrix

WHITES --MORE THAN $3000

GRADE	ACHIEVEMENT ENGLISH	ACHIEVEMENT MATH	TRUANTS	DROPOUTS
2.9	2.5	2.52	9	0
3.9	3.3	3.30	10	0
5.2	5.3	5.26	7	0
6.2	6.6	6.57	7	0
8.2	8.4	8.45	4	0
10.2	10.7	10.70	0	0

EQUALITY OF EDUCATIONAL OPPORTUNITY

GRADE = 10.0 ENGLISH = .31 MATH = .31

	NUMBER	POTENTIAL LIFETIME EARNINGS	EXPECTED LIFETIME EARNINGS
GRADE 6 DROPOUTS	0	47390	47021
GRADE 10 DROPOUTS	0	91987	91321
GRADE 12 DROPOUTS	26	98918	98260
VOCATIONAL	193	100384	100020
COMMERCIAL	480	87529	87209
ACADEMIC	299	129325	129140
TOTAL	1000	102757	102460

TABLE V-24: Compensatory and Non-Compensatory Schools Compared with Respect to Stanford Reading Test Scores and Changes

	AVERAGES		CHANGES	
	Comp.	Non-Comp.	Comp.	Non-Comp.
Grade 1	1.58	1.96	.02	.00
Grade 2	2.14	2.95	.03	.00
Grade 3	2.73	3.91	-.01	-.15

APPENDIX A

HOW TO USE THE MODEL

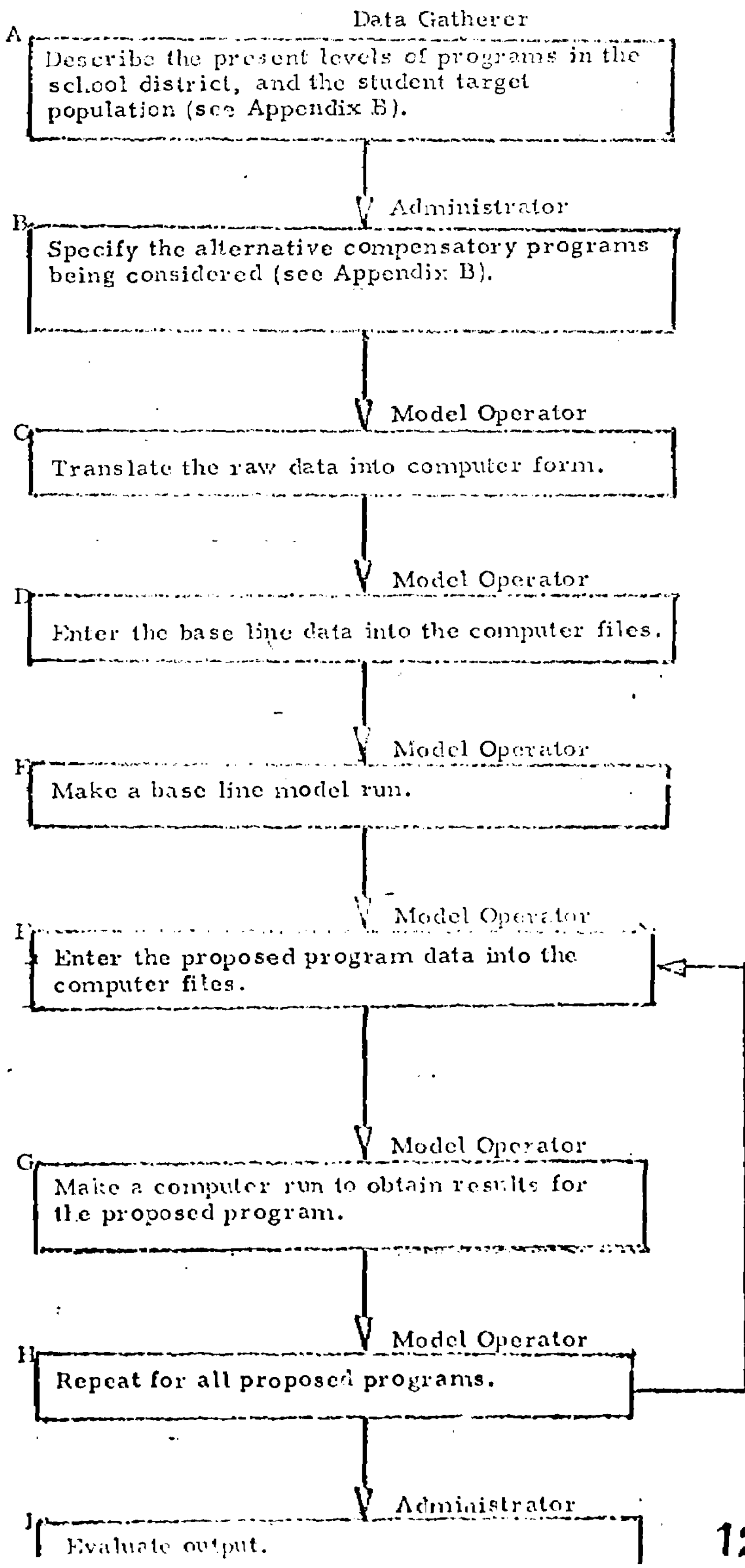
The OECE Model will have several types of users: the data gatherer, who collects the information necessary to describe the school district being studied; the administrator, who provides input for the data gatherer, specifies the alternative compensatory programs under consideration, and decides which combination of compensatory programs will be implemented; the data interpreter and executor of the computer program (hereafter referred to as the model operator). The flow chart in Figure A-1 shows the sequence of operations that must be followed to operate the model successfully.

This Appendix will concentrate on the tasks of the model operator. Appendix B describes the forms included in the OECE Model and the directions for applying them. These directions define the task of the data gatherer. A portion of the administrator's task is also described, since he must fill out the section of the form dealing with proposed compensatory programs. Evaluating the output of the model, the other task of the administrator, is described in Chapter III. 7.

The model operator should have some mathematical ability and should know computer programming. He should have a working knowledge of the model, and know the organization and techniques of the computer program. He should also be familiar with educational processes, and he will be called upon to exercise some judgment in translating the from the user forms into computer input form when data forms from the school district are incomplete. Thus, his judgment, accuracy, and clarity significantly affect the quality of the cost-effectiveness evaluation.

The tasks which the model operator must perform are listed in boxes C through H of the flow chart in Figure A-1. Each of these will be described in the following sections.

FIGURE A-1


Data Gatherer
A
Describe the present levels of programs in the school district, and the student target population (see Appendix B).
Administrator
B
Specify the alternative compensatory programs being considered (see Appendix B).
Model Operator
C
Translate the raw data into computer form.
Model Operator
D
Enter the base line data into the computer files.
Model Operator
E
Make a base line model run.
Model Operator
F
Enter the proposed program data into the computer files.
Model Operator
G
Make a computer run to obtain results for the proposed program.
Model Operator
H
Repeat for all proposed programs.
Administrator
I
Evaluate output.

TASK C: TRANSLATION OF THE RAW DATA INTO COMPUTER INPUT FORM

Complete data for a school district using the model should be contained in a user form (Appendix B) which has been properly filled out. It is assumed that the values of the program constants (weighting factors, Markov matrices, regressive coefficients relating dropouts and truancies with achievement levels, etc.) are set from prior information. The degree to which these constants will change is not known from school district to school district. They might change due to regional differences. For example, state laws controlling minimum dropout ages differ. This affects the constants which relate dropout rates to achievement as a function of grade. Changes in parameters of this type are discussed in Appendix C.

The various entries in the user form must be related to the data files of the program. For example, information about a service being new must be stored in the file called NEW. Table A-II shows the connections between the user form entries and the program files. Each file has a related question which supplies data for it. From the model operator's point of view, files are divided into three distinct types:

1) files are requiring only a transfer of data, or a translation of a Yes or No answer into 1 or 0;

2) files requiring that the data be scaled between 0 and 1;

3) files requiring other computation.

The format of each files is discussed in appendix D. Type 1 files need quantities transferred from the user form to the files according to the specified formats, with no intervening calculations. They are rather straightforward and require no further discussion.

Type 2 files do require calculations. These describe the strengths of the components of the compensatory education programs either programs presently in effect, or proposed programs. Each of these variables must be scaled to a value between 0 and 1. Each

TABLE A-II

LINKAGE BETWEEN COMPUTER FILES AND THE QUESTIONNAIRE

File Type	File Name	Meaning	Matrix Dimensions	Questionnaire Reference
1	LASTI	Number of students in grade previous to IN-YEAR*	student type	1d, 5h, 5i, 5j, 5k, 3g, 3h
1	SRVICS	Number of services	student type, grade	5a, 6a
1	REL	Relevance of services to disadvantage factors	type, service, disadvantage	5o, 6k
1	NEW	Service new or not?	service, grade, type	5c, 6c
1	FREE	Service free or not? (Always free for Title I programs)	service, grade, type	--
2	PARA	Number of para-professionals/student	service, grade, type	5d, 5h, 5i, 5j, 5k 6d
2	SPACE	Space per student	service, grade, type	5e, 6e, 5h, 5i, 5j 5k
2	SBUDGT	Dollars per student	service, grade, type	5f, 6f, 5h, 5i, 5j, 5k
2	SHOURS	Hours per day using service	service, grade, type	5l, 6h
2	SDAYS	Days per week using service	service, grade, type	5m, 6i
2	SWEEKS	Weeks per year using service	service, grade, type	5m, 6j
3	DIS	Students' disadvantage factors	test, grade	4a, 4b, 4c, 4d, 4[illegible]
2	RECEN	Recency of curriculum material	test, grade	7a, 8c
2	TCHEXP	Average teacher experience	test, grade	7b, 8d
2	TCHRS	Teacher/pupil ratio	test, grade	7c, 8c
2	TEXTS	Text/pupil ratio	test, grade	7d, 8f

TABLE A-II -- Continued

File Type	File Name	Meaning	Matrix Dimensions	Questionnaire Reference
2	DESKS	Desk/pupil ratio	test, grade	7e, 8g
2	TCHBUD	Instructional budget	test, grade	7f, 8h
2	CTHRS	Hours/day instruction	test, grade	7g, 8i
2	TCHDYS	Days/week instruction	test, grade	7h, 8j
2	TCHWKS	Weeks/year instruction	test, grade	7i, 8k
3	INGLEV	Grade level achievements in grade before INYEAR	test, grade, type	2a, 2b, 2c, 2d, 2e, 2f
3	PPINIT	Percentages of students over and under the threshold score in the grade before INYEAR	test, grade, type	2g, 2h, 2i, 2j
3	STATIN	The achievement gains per year	test, type	2k
1	INIT	Number of grades tested, number of student types, initial grade of the Title I program, the test norms for each grade tested	--	1f

*INYEAR denotes the first grade in which the Title I program is in effect

/Test the test categories of the achievement tests administered. Two categories are presently allowed: scientific and non-scientific.

Each variable is assumed to have a minimum value below which the reduction of the Title I program component has no lessening effect on student performance, and a maximum value, above which an increase of the Title I program component has no further beneficial effect on student performance. The value of the variable is computed by:

$$\text{Variable} = \frac{\text{Value} - (\text{Min Value})}{(\text{Max Value}) - (\text{Min Value})}$$

For example, PARA contains the numbers of para-professionals associated with the various Title I service components. Suppose that the service being considered is a health service, and that the para-professionals are nurses. Suppose further that the proposed Title I program has provision for three nurses. The minimum number of nurses is 0. Let us choose the maximum number of nurses to be twelve. Beyond that value, the school system is considered to be overstaffed with nurses, and adding more has no beneficial effect. The variable scaling is calculated as:

$$\text{Variable} = \frac{3 - 0}{12 - 0} = .25$$

This proposed Title I program, with a linear measure of program magnitude, has gone one-fourth of the way toward satisfying the school system's requirement for nurses. Since the selection of the minimum and maximum values of the variables is left to the model operator. His familiarity with educational processes is important.

A linear measure has been chosen here, but the sophisticated user could employ non-linear measures. For example, if he decided that three nurses would be so overworked and inefficient that they would be only slightly better than none at all, he might decide to enter the value .1 into PARA. However, if no better information is available, a linear measure seems to be a reasonable choice.

Note that all Type 2 variables describe the strengths of the Title I program components. Type 3 variables describe the characteristics of the student population in the grade immediately before that in which the Title I program takes effect. All of the information for filling the Type 3 data files is contained in the Student Record Sample Questionnaire (SRSQ) of the User Form in Appendix B. There are four Type 3 files. They are:

1) DIS - The percentages of students having each of the six factors of disadvantage described in Chapter III. 4. This computation is straightforward and has been described in the SRSQ.

2) INGLEV - The average grade level equivalent achievement in each test category of each student type in the grade immediately preceding that in which the Title I program is first applied. These computations are also straightforward sampling and averaging procedures and are described in the SRSQ.

3) STATIN - The grade level achievement rates in each achievement test category in the grade preceding Title I application. These numbers are obtained from the SRSQ. The change in grade equivalent achievements per year is the required quantity. This is obtained by subtracting two consecutive achievement test scores for each student sampled, and dividing by the number of years between the tests. For example, if student A had test scores in Math of 3.1 and 5.6 in years 3.2 and 5.8 respectively (Title I being applied in grade 6), his achievement rate is:

$$\text{Rate} = \frac{5.6 - 3.1}{5.8 - 3.2} = \frac{2.5}{2.6} = .96$$

These rates can be averaged over all students of the student type being considered.

4) PPINIT - The percentages of students of each student type whose test scores are above and below the achievement threshold

(See Chapter III. 5) for the combinations of achievement test categories. For example, if the threshhold is the national norm, it would be the percentage of students who were below in both English and Math categories, the percentage who were below in English but above in Math, the percentage who were above in English but below in Math, and the percentage who scored above the norm in both subjects (in the order shown). This process is again a simple categorizing of members of the sample in the SRSQ; i.e., counting the members in each category, and dividing by the total number.

After these computations are accomplished, the variables should be in the proper forms to be input to the data files. There will be several groups of information, one group for the base line case (without the proposed Title I Programs) and one group for each of the proposed compensatory education programs. Some files will not change from base line to non-base line runs; e.g., DIS - the percentages with each disadvantage factor.

TASK D: ENTER THE BASELINE DATA INTO THE COMPUTER FILES

To accomplish the base line run, all of the files in Table A-II must be filled with base line information. The formats and exact configuration of each file is shown in Appendix D. The operator must call each file to be filled into the time sharing computer memory, fill or change the file, and store it again into permanent storage. The sequence of time sharing commands which accomplish this is described below. Statements printed by the computer are underlined, while those typed by the operator are enclosed in quotation marks.

"OLD"

OLD FILE NAME -- "PARA" (or the appropriate file)

READY

(At this point, the data can be entered following the formats described in Appendix D, e.g.)

"1000 1 1 0.25 0.30 0.12"

"2010 1 2 0.30 0.85

(etc.)

"SAVE"

READY

The computer is nowready to accept the command "OLD" to initiate the sequence again for the next file. After all the data files are filled in this manner, the model is prepared for a base line run.

Base line runs are needed only once for a particular school system if the only changes for subsequent runs are in the files containing the strengths of the various compensatory program components. If any change is made in the program constants or in the student body characteristics, another base line run is necessary.

A base line run fills the files OLDZ, OLDC, and OLDSER, which are base line values of the impedence, instruction, and service respectively. If it is desired to save the results of a base line run for later use, it is sufficient to save only these three files. Reading them back into the files is equivalent to making the same baseline run.

TASK E: MAKE A BASELINE RUN

After the base line values of the program components have been placed in the files, making a base line run is simply a matter of running the program. The file containing the initial section of the program is MAIN. If this file is called into memory and run, it will call all subsequent programs, and stop after the final output. The only operator intervention required is to tell the program if the run is base line or not. The computer will print

IS THIS A BASE LINE RUN? 1 IF YES: 0 IF NO

? "1"

The answer is one in this case, a base line run. The exact sequence of instructions which start the program is as follows:

"OLD"

OLD FILE NAME -- "MAIN"

READY

"RUN"

TASK F: ENTER THE PROPOSED PROGRAM DATA INTO THE COMPUTER FILES

This task is accomplished in the same manner as Task D, the difference being that the data input is non-base line data. See the description of Task D for the details.

TASK G: MAKE A COMPUTER RUN FOR THE PROPOSED PROGRAM

This task is accomplished in the same way as Task E, except that the operator types 0 instead of 1 when computer asks if the run is base line or not. See the description of Task E.

TASK H: REPEAT RUNS FOR ALL PROPOSED PROGRAMS

Each proposed Title I Program implies changes in some of the variables describing the strengths of the program components. Tasks F and G must be repeated for each of the Title I programs being considered.

After the program has been run for each of the Title I programs, and for the base line case, the administrator can compare the outputs to weigh changes in operation and funding against the results which the model estimates and projects in the future.

APPENDIX B

TO THE SUPERINTENDENT

After you have completed your share of these forms, and the Office of Education has analyzed them with the help of computers, you will be able to evaluate the effectiveness of any compensatory or instructional improvement programs you contemplate adopting under Title I of the Elementary and Secondary Act of 1965 (as amended in 1967), with much greater accuracy and detail than was previously possible.

We have made every effort to make the questionnaire as painless and rapid as possible for your office and the individual school offices to fill out, while providing the degree of detail necessary for accurate analysis by computer. For your convenience, we have organized step-by-step instructions (beginning on the next page) for finding and filling in answers to the questions. Please, follow the instructions exactly and in order!

Some of the information can be filled out immediately on the final sheets that are eventually to be returned by us (these are all on blue paper). You can complete all additional information requirements by sending out sub-questionnaires (white paper and photocopies of some partially-completed blue sheets) to selected schools, compiling the results, and copying the final figures on the blue sheets.

The Superintendent's Office should be able to complete the blue master questionnaire sheets--both questions which are immediately answerable of data from selected schools-- in a total of one man-day or less, compilation if adding and photocopying machines are available. Each selected school can complete the work on the white and photocopies sub-questionnaire sheets in about the same time.

SUMMARY AND INSTRUCTIONS FOR USING THE EDUCATIONAL EFFECTIVENESS QUESTIONNAIRE

Summary

The questionnaire requires information from five different sources in the school system:

	BLUE QUESTION; PART	
1. The superintendent's central school office should have information in proper form for questions.	1: a, b, c, d	= Group 1.
2. The superintendent's judgment, and that of his advisors, provide information for questions.	6: a, b, c, d, e, f, g, h, i, j, k 8: a, b, c, d, e, f, g, h, i, j, k	= Group 2.
3. Each school in the district should have information in proper form for questions.	5: g 7: a, b, c, d, e, f, g, h, i	= Group 3.
4. A brief survey of teachers in representative schools will provide information for questions.	5: a, b, c, d, e, f, h, i, j, k, l, o	= Group 4.
5. A small statistical sample of pupil records in representative schools will provide information for questions. . . .	1: e, f 2: a, b, c, d, e, f, g, h, i, j 3: a, b, c, d, e, f, g, h 4: a, b, c, d, e	= Group 5.

Groups (1) and (2) can be filled out by the superintendent, his advisors and his office immediately on the blue master sheets. For the other three groups it is necessary to choose representative schools and send white sheets and photocopies of partially-completed blue sheets to them. They can fill out group (3) immediately. Group (4) requires each selected school to conduct a small survey of teacher judgment, and Group (5) requires a small sampling of pupil records. Answers from the various representative schools are then averaged and compiled, and the results are entered on the master blue sheets. This completes the questionnaire, which is then returned to us.

<u>The blue sheets, and only they, contain all the information in final form.</u>

Instructions

1. The Superintendent's Office should fill directly onto the blue sheets in answers to Group (1) questions, plus any other questions it can answer from its files.

2. The superintendent and his advisors on compensatory and instructional improvement programs should meet and fill in answers to Group (2) together. Each proposed

program need not be listed on a separate copy of Question 6 or 8. Ten copies of each are provided. If more programs are to be evaluated, simply photocopy the sheets for as many as are desired. Each set of answers should be numbered for future reference where indicated.

3. The superintendent's office should fill in the "Condensed Questions 5 and 6" sheets. This involves copying the services listed in question 5 and all the versions of question 6, taking care to list, just once, all of the services used in the various programs, filling in no other blanks.

4. Representative schools should be chosen to answer the remaining question according to the instructions entitled "Selecting Representative Schools."

5. Partially-completed questions 1, 5, and 6, and "Condensed Questions 5 and 6" should be photocopied with enough duplicates for all schools (see below).

6. Each school should be sent the following items in the following numbers:

1	introductory letter
1	photocopied partially-completed question 1
1	photocopied partially-completed question 5
1	photocopied partially-completed question 6
4	photocopied "Condensed Questions 5 and 6"
6	blank question 2 (white)
1	blank question 3 (white)
1	blank question 4 (white)
1	blank question 7 (white)
1	"Conducting and Compiling the Teacher Survey"
1	"Conducting and Compiling the Pupil Record Sample"
12 or 24*	Pupil Record Sample Questionnaire"

Note that no blue sheets should be sent out to schools; they are master copies to be kept by the superintendent's office.

7. After the schools have returned the completed sheets, results for each question should be compiled, using the instructions entitled "Compiling the School Questions." Then these final figures should be entered on the blue master questionnaire.

8. The completed blue questionnaire should then be sent to us for analysis.

NOTE: You may find that some sheets do not have enough vertical space for all your information. Simply add as many sheets as necessary, and continue with the same placement of columns.

* 12 for junior high and senior high, 24 for elementary

SELECTING REPRESENTATIVE SCHOOLS

The questionnaire kit includes materials for sampling nine schools in your district (three elementary, three junior high, and three senior high). If you have all three levels of schools, you should sample no less than nine. Sampling less than three schools per level may produce less accurate information than is desirable for the analysis. You may sample more if you like, simply by photocopying additional sheets.

The following steps give a "selection procedure" for choosing schools that accurately reflect yourwhole school district. If the district is too small to apply these techniques directly, choose schools from a wide range of incomes and locations, but with three elementary-junior-senior "clusters." The schools in each cluster should be in the same geographical area.

1. List all the senior high schools in the district. Then eliminate schools that are considerably above or below average size.

2. From these, choose the schools with most compensatory services already provided or, if few are provided, where compensatory services are most needed. A good number to choose is fifteen in a large district.

3. Arrange these schools roughly in order according to the part of town and parents' income bracket. (Use the table on the next page, if it is helpful.) Then choose the top four, four from the middle, and the bottom four.

4. Now repeat this procedure for elementary and junior high schools.

5. Take the four top schools for each level and select one from each level to make a "cluster" of three reasonably close together.

6. Do the same for the bottom four. This "cluster" should be as far away geographically as possible from the "richer" cluster.

7. Finally, do the same for the "middle" group, again trying to locate this "cluster" as far away from the other two as possible.

The nine schools chosen by this method should give a good indication of the general condition of your school district.

	Elementary	Junior High	Senior High
op"			
middle"			
ottom"			

Letter of Introduction to be Sent with Questionnaires
to Each School Principal

Dear Sir:

Your school has been chosen by the Superintendent's Office to participate in an evaluation of various programs which are being considered by the Office of Education for adoption under Title I of the Elementary and Secondary Education Act of 1965 (as amended in 1967).

You can contribute to this evaluation by supplying information about your school for a questionnaire which the Superintendent is required to submit. The Office of Education has attempted to make your part of the questionnaire as short and simple as possible. However, a certain degree of detail is necessary to insure accurate computer analysis.

Some of the information may be filled in immediately. The rest may be obtained by a survey of a few teachers in your school and from a sampling of your pupil records and averaging a few important details. For your convenience, step-by-step instructions have been included beginning on the next page.

If you have an adding machine at your disposal, you should be able to complete these questions in one man-day. Please follow instructions precisely and in the order which they appear!

Sincerely yours,

CONDUCTING AND COMPILING THE TEACHER SURVEY

With the materials you have received from the Superintendent's Office you should find the following:

4 copies of "Condensed Questions 5 and 6"
1 copy of photocopied, partially-completed "Question 5"
1 copy of photocopied, partially-completed "Question 6"

These are to be used to survey four teachers and various special service aides in your school for their opinions of existing and contemplated new programs.

Choose one mathematics teacher, one science teacher, one English teacher, and one history teacher. They should be familiar with the school's facilities and have considerable teaching experience. Department heads are ideal if they have been at the school several years; but if a department head is new, it is better to choose a teacher who has been around longer.

Circulate "Condensed Questions 5 and 6" among all paraprofessionals who are actively involved in the extra-instructional services listed on the question sheet. This includes counselors, recreational aides, dieticians, nurses, special activities leaders, librarians, teachers' clerical aides, assistants for physically handicapped students, school-home liasons, special facilities caretakers and operators, etc. Have each person fill out the rows of blanks on the sheet which applies to the service he is associated with.

Take "Question 5" and "Question 6" and fill them in using simple averages of the paraprofessionals' answers on "Condensed Questions 5 and 6."

This completest the teacher survey.

CONDENSED QUESTIONS 5 AND 6

a. List compensatory services currently offered (counseling, free lunches, anything not related to instruction or to contemplated Title I Programs.	b. Enter numbers of grades in which service is offered.

c. Is the service new?	d. Enter the number of para-professionals associated with service	e. Enter amount of space used for service (sq. ft., no. of classrooms, etc.)	f. Enter total number of students participating in service	Break down total number into numbers of race and family income, as follows g. None-white under $3,000

h. Non-White, $3,000 or over	i. White under $3,000	j. White, $3,000 or over	Amount of time typical participant spends on service. k. Hours /day	l. Days /week	m. Weeks /year

n. Enter disadvantage(s) that each service is specifically designed to help compensate for, by this code: (0) - none of these; (1) = family poverty; (2) = parents' low level of education; (3) = physical handicaps; (4) = broken family situation; (5) = whole - class ach. lag; (6) = individual achievement lag.

CONDUCTING AND COMPILING THE PUPIL RECORD SAMPLE

With the materials you received from the Superintendent's ffice should be included with the following:

1	photocopied, partially-completed "Question 1"
6	blank "Question 2"
1	blank "Question 3"
1	blank "Question 4"
12 or 24*	"Pupil Record Sample Questionnaire" (PRSQ)

You will file these in with information from your files about your school's student body.

Some of the information can be filled out immediately from your records, as follows:

1. Fill in question (1d) for each grade in your school.

2. Fill in question (1f) for each grade in your school from records of standardized tests for as many as 6 test sets.

3. Also from these records, fill in (2a), (2b), (2c), and (2f), using separate copies of Question 2 for each test set, one of which must be for the first-grade entrance test set.

4. Fill in question (4e) by looking up achievements for each class section to find which are achieving 3/4 or less of their grade level and adding up the total number of students in all of these achievement-lag classes.

The rest of the information must be gathered by sampling fifty pupil records from your files. It is assumed that the student records contain at least the following information on each student:

- race
- family's income
- achievement test scores and percentiles for each test set indicated in question (1j)
- approximate parents' level of education
- indication of physical handicaps
- parents' marital status
- indication of truancy or dropout status

If any of this information is not given, either estimate it for the final figures and averages, or make a note and explain on a separate sheet.

5. To choose the student sample, first take the number of students in your school and divide exactly by 50. Call the result "T." Round T off to the next higher whole

* 12 if your school is junior high or senior high, 24 if elementary

number and call this result "U." Now go through the student records for the whole school and take out every U^{th} record, going in alphabetical order. This group of records is the sample.

6. Next separate the records into one pile for each grade in your school. Then separate each pile into two piles, one for white and the other for non-white. Finally, separate each of these piles into two piles, one for family income under $3,000 a year, the other for $3,000 or over. You should now have four piles for each grade, as follows:

	White		Non-white	
	over $3,000	under $3,000	over $3,000	under $3,000
Grade--	(pile)	(pile)	(pile)	(pile)
Grade--	(pile)	(pile)	(pile)	(pile)
Grade--	(pile)	(pile)	(pile)	(pile)

.
.
.
(etc.)

7. Fill out a PRSQ for each of these piles, making sure to compute the sum and averages at the bottom of some of the columns.

8. Group together all four PRSQ's for each grade separately. Add up the numbers of sample students (N's) for all types together in each separate grade. Enter the results in (1c) for each grade.

9. Now re-group all PRSQ's together for each of the four race-income types separately. Add up and average the scores for each test set for all grades together in each separate type. Enter these in (2d) and (2e) for each race-income type.

10. Keep the PRSQ's grouped by race-income type. Add up the numbers of mAvB, mBvA, mAvA, and mBvB students, for all grades together in each separate type. Enter these sums in (2g), (2h), (2i), and (2j) for each race-income type.

11. Keep the same grouping. Add the numbers of dropouts, for all grades together in each separate type. Enter these sums in one of (3a), (3b), or (3c), depending on the level of your school, for each race-income type.

12. Repeat for truants, and enter the sums in one of (3d), (3e), or (3f), depending on the level of your school, for each race-income type.

13. Add and average the "I N" entries, for all grades together in each separate type. Enter these sums in (3g) by race-income type.

14. Enter the number of students in each socio-economic group in (3b).

15. Likewise, add the numbers of parents with elementary school education or less, for all grades together in each separate type. Enter this sum in (4b).

16. In the same way, add the following items for all grades in each separate type and enter the sums as follows:

Number of students with physical handicaps............ (4c)

Number of students whose parents are divorced or separated.......... .... (4d)

Number of students whose scores on one or more achievement test were 3/4 or less of their school grade numbers ....(4f)

This completes the pupil record sample. When this and the teacher survey are both complete, please return to the Superintendent's Office all sheets of Questions 1, 2 (all of them), 3, 4, 5, 6 and plus any explanatory notes you have made.

Thank you for your patience.

PUPIL RECORD SAMPLE QUESTIONNAIRE Grade ___ (Over / Under) $3,000

Students' codes	Test set at entrance to grade 1				Test set given here in grade ___ month ___				Test set given here in grade ___ month ___			
	MATH		ENGLISH		MATH		ENGLISH		MATH		ENGLISH	
	Score	A if above, B if below 17th perc.	Score	A if above, B if below 17th perc.	Score	A if above, B if below 17th perc.	Score	A if above, B if below 17th perc.	Score	A if above, B if below 17th perc.	Score	A if above, B if below 17th perc.

No. of students	Sum	Sum	Sum	Sum	Sum	Sum
N = ______	S = ______	S = ______	S = ______	S = ______	S = ______	S = ______
N x T = ______	S/N = ______	S/N = ______	S/N = ______	S/N = ______	S/N = ______	S/N = ______
	mAvB ____	mBvA ____	mAvB ____	mBvA ____	mAvB ____	mBvA ____
	mAvA ____	mBvB ____	mAvA ____	mBvB ____	mAvA ____	mBvB ____

(White / Non-white)

Test set given here in grade _____ month _____				Test set given here in grade _____ month _____				Test set given here in grade _____ month _____				Enter "1" if dropped out	Enter the number of times the student was truant last year.
MATH		ENGLISH		MATH		ENGLISH		MATH		ENGLISH			
Score	A if above, B if below 17th perc.	Score	A if above, B if below 17th perc.	Score	A if above, B if below 17th perc.	Score	A if above, B if below 17th perc.	Score	A if above, B if below 17th perc.	Score	A if above, B if below 17th perc.		

Sum S = _____ S/N = _____ | Sum S = _____ S/N = _____ | Sum S = _____ S/N = _____ | Sum S = _____ S/N = _____ | Sum S = _____ S/N = _____ | Sum S = _____ S/N = _____ | Sum of dropouts = _____ | Sum = _____ S/N = _____

m _____ mBvA _____ mAvB _____ mBvA _____ mAvB _____ mBvA _____

m _____ mBvB _____ mAvA _____ mBvB _____ mAvA _____ mBvB _____

Enter est. family income	Enter "1" if parents' have elem. ed. or less	Enter "1" if physically handicapped	Enter "1" if parents divorced or separated	Enter "1" if any test was 3/4 or less of grade level when given	

Sum Sum Sum Sum Sum

S( ) ______ ______ ______ ______ ______

S/N =

COMPILING THE SCHOOL QUESTIONS

When you have a set of seven completed white questions from each of the selected schools, it is a simple matter to average the results and enter them on the blue master sheets.

First, go through each school's responses and check to make sure that all questions that should have been answered are filled in, or noted with an explanation. Those questions are those in groups 3, 4, and 5. Anywhere an answer has been left out, make a note on a separate sheet, so that you can contact the school if necessary. If one or two schools omit a particular item that is filled in by all the others, the final statistics will still be valid; but if more than this omit a question, they should be culled and some estimate should be made of the information.

Next, gather together all the schools' replies to each question separately, so that you can tabulate each question as a unit.

Add up all the responses to each blank and then take the average, making sure to divide by just the number of schools answering the question. Then enter the averages on the blue master sheets. A convenient way to do this is to enter the undivided sums and their divisors on the spare questionnaire provided. Then, as each division is performed, the final answer can be entered on the blue sheet and that box crossed off the spare.

This complete the Educational Effectiveness Questionnaire. Simply send us the master blue sheets completely filled in. Our analysts and computer will begin work on the questionnaires as soon as we receive them, and we will send you results as soon as possible within three weeks.

Thank you for your patience.

QUESTION 1 BLUE

a. List each grade in the school district.

b. For each grade, make a check (✓) if there are any compensatory programs in effect for that grade, and an "x" if not.

c. Make checks in the same set of boxes checked in b, and then add checks in boxes of years just preceding those checked in b. Put x's in the remaining boxes.

d. Enter the total number of students in each grade in the school district.

e. Enter the number of students in the student sample, for each grade

f. For first grade plus each grade checked in c, enter "x's" for grades in which no standardized verbal and/or mathematical tests were administered, and enter the number of the month in which such tests were administered.

a.	1st			
b.				
c.				
d.				
e.				
f.				

Place a check in boxes beneath boxes in which checks appear. Now place a check in any box immediately to the left of a checked box. Now place X's in remaining empty boxes.

BLUE

BLUE

QUESTION 2

NOTE: Please fill out one of these forms for each test set indicated in question 1, part f, starting with first grade, going on to the next test set, etc.

a. Name of type of test: ______________________________

b. Grade: ______ Month: ________

c. If test gives only one score, combining mathematics and [ ] English, use boxes for question (d.) and check here.

		Non-white under $3,000	Non-white $3,000 or over	White under $3,000	White $3,000 or over
d. Enter average scores on mathematics section, for each income-race type. If possible, use grade level equivalent scores.	d.				
e. Enter scores for verbal section. If two sections scored separately.	e.				

f. If grade level equivalent scores were not used, check here and please include with the returned questionnaire the conversion method for finding grade level [ ] equivalents.

g. Enter number or percentage who scored above the 17th percentile on the mathematical and below it on the English sections.	g.				
h. Enter number or percentage who scored above the 17th percentile on the English and below it on the mathematical sections.	h.				
i. Enter number or percentage who scored above the 17th percentile on both sections.	i.				
j. Enter number or percentage who scored below the 17th percentile on both sections.	j.				

k. Enter the achievement rates (grade levels/year)				

QUESTION 3 BLUE

		Non-white under $3,000	Non-white $3,000 or over	White under $3,000	White $3,000 or over
a. Enter number of dropouts from elementary school.	a.				
b. Enter number of dropouts from junior high school.	b.				
c. Enter number of dropouts from senior high school	c.				
d. Enter number of truants in elementary school.	d.				
e. Enter number of truants in junior high school.	e.				
f. Enter number of truants in senior high school.	f.				
g. Enter the <u>average</u> income of each of the four groups listed.	g.				
h. Enter number of students in each group.					

QUESTION 4

BLUE

	Non-White Under $3000	Non-White $3000 or over	White under $3000	White $3000 or over
a. Enter the number or percentage of students whose parents have only an elementary schools education or less				
b. Enter the number or percentage of students who have physical handicaps.				
c. Enter the number or percentage of students who have less than two parents at home.				
d. Enter the number or percentage of students in classes for which the over-all class average on achievement tests is only 3/4 or less if its school grade level.				
e. Enter the number or percentage of students whose scores on one or more achievement tests were only 3/4 or less of their school grade level.				

QUESTION 5

BLUE

a. List compensatory services currently offered (counseling, free lunches, anything not related to instructions).

b. Enter numbers of grades in which service is offered.

BLUE

c. Is the service new?	d. Enter the number of paraprofessionals associated with service.	e. Enter amount of space used for service (sq. ft., number of classrooms, etc.)

BLUE

Enter total budget of service	g. Enter total number of students participating in service	h. Non-white under $3000	i. Non-white $3000 or over	j. White, under $3000	k. White, $3000 or over

Break down total number into numbers of students by race and family income, as follows: (columns h–k)

Amount of time typical participant spends on service.

l. Hours (/day	m. Days /week	Weeks /year		Enter disadvantage(s) that service is specifically designed to help compensate for, by this code: (0) = none of these; (1) = family poverty; (2) = parents' low level of education; (3) = physical handicaps; (4) = broken family situation; (5) = whole class ach. lag; (6) = individual ach. lag.
( )				

Program number ______ BLUE

QUESTION 6 (One for each Program) (Fill out one form for each contemplated program of services; after a row of blanks has been filled out describing a given service, that service can be used in other programs without recopying the row of blanks.)

a. List the services making up one contemplated program which might be adopted under Title I.	b. Enter numbers of grades for which service would be offered.	c. Would the service be entirely new?	d. Enter the number of paraprofessionals to be associated with service

e. Enter amount of space to be used in service (sq. ft., no of classrooms, etc.).	f. Enter total budget of proposed service.	g. Enter total number of students to participate in service.	Amount of time typical participant spends on service.		
			h. Hours /day	i. Days /week	j. Weeks /year

BLUE

k. Enter disadvantage(s) that service is specifically designed to help compensate for, by this code: (0) = none of these; (1) = family poverty; (2) = parents' low level of education; (3) = physical handicaps; (4) = broken family situation; (5) = whole - class ach. lag; (6) = individual achievement lag.

QUESTION 7

	a. Enter average publication date of textbooks currently used.	b. Enter average current teacher experience (years).	c. Enter average number of pupils per teacher.	d. Enter average number textbooks per pupil.
Mathematics, science, related courses				
Elem. 1 thr. 3				
Elem. 4 thr. 6				
Junior High				
Senior High				
English, writing, history, literature, related courses				
Elem. 1 thr. 3				
Elem. 4 thr. 6				
Junior High				
Senior High				

BLUE

e. Enter average number desks per pupil.	f. Enter average annual Instructional Budget.	Enter average class time Hrs. /day	Days /week	Wks. /year

Program number________

BLUE

QUESTION 8 (One for each Program)

Fill out one form for each contemplated program of instructional revision; after a row of blanks has been filled out describing a given change, that item can be listed in other programs without recopying the row of blanks.

a. List the instruction-related revisions making up one contemplated program that might be adopted under Title I.	b. Enter grades affected	c. Enter average publication date of text-books to be used.	d. Enter intended teacher experience.	e. Enter intended number of pupils per teacher.

BLUE

Enter intended number of textbooks per pupil.	g. Enter intended number of desks per pupil.	h. Enter intended Instructional Budget.	Enter intended class time: i. Hours /day	j. Days /week	k. Weeks /year	

APPENDIX C

CHANGING THE MODEL

The OECE model is based on the assumtion that the educational process can be accurately simulated using a finite number of analytical variables. These variables have certain functional relationships among themselves, and various parameters, or weighting factors, control the magnitude and sign of these relationships.

The authors recognize that in school systems with different environmental conditions, certain factors specified in the present analysis in the model may affect the education of a group of students differently than is presently indicated by the weighting factors of the model. In addition, new educational and environmental factors may influence the students. The user may then desire to change several of the weighting factors, and possibly add new variables with respective weighting factors. As the model is presently programmed, it is easy to change the weighting factors. The method for doing this will be discussed below. The other type of change which seems most likely is adding a variable in one of the equations. For example, if future research shows that a teacher's age significantly affects the performance of his classes, then this variable should be added in to the equation of teacher quality. (Subtracting variables from the equations is a much simpler process--simply set its weighting factor to zero).

1. Changing a weighting factor.

Weighting factors are discussed in Chapter III. A comprehensive list of files containing them is presented in Appendix D. After deciding which file must be changed, and what the new values are, the file can be called into the computer and changed. The user-computer dialogue should look as follows (computer statements are underlined, user statements are enclosed in quotation marks):

"OLD"

<u>OLD FILE NAME</u> -- "(File Name)"

READY

"LIST"

(The contenst of the file are listed)

When the user has located the specific number or numbers he wishes to change, he must retype the line or lines containing the numbers exactly as they appeared before, except for those to be altered. The formate's of all of these files are presented in Appendix D. After the changes have been made, it is wise to list the file once more, both for purposes of obtaining a clean copy of the altered file, and for checking the changes to see if they have been properly made. The file can then be sent to permanent storage. The computer command sequence is as follows:

"LIST"

(The contents of the file are listed)

"SAVE"

<u>READY</u>

2. Adding a new variable to the model.

This type of change is relatively complicated, and causes changes in several locations. The following files are affected:

a) The variable file--a new one must be created.

b) The weighting coefficient file -- an extra value must be added. (thereby changing the dimensionality)

c) The computing sub-routine--the statement in the relevant sub-routine which computes the expression being altered must be changed.

d) The MAIN Program--

    i) the statement which reads the file into memory must created.

    ii) the dimensions of the weighting coefficient must be changed in the statement which reads the weighting coefficient file.

e) The $ FILE statement -- the new file name must be added.

f) The COMMON statement (in every sub-routine)--the new variable name must be added, and the dimension of the weighting factor must be changed.

Each of these changes (with the exception of a) is accomplished by calling in the particular file, retyping the line to be changed, and storing the result. The command sequence is:

"OLD"

OLD FILE NAME -- "(File name)"

READY

(change the necessary lines)

"SAVE"

READY

Step a) involves creating a new file. The command sequence is:

"NEW"

NEW FILE NAME -- "(File name)"

READY

(Type in the file information according to the format of a similar file (see Appendix D))

"SAVE"

READY

Step d) involves changing the dimensions of the variables in the read statements. Most files are read by means of two input/output sub-routines--READ for vector input, and READ 1 for matrix input. The dimensions of the vector or the matrix are present in the calling sequences. The exact form of the calling sequence is described in the program listing of Appendix F (See the listing of READ, and READ 1).

An emperical way of effecting this type of change is to consider variables of the same type as the one being created. For example, if teacher age is taken to be another variable in the calculation of teacher quality, then it should be treated in the same way as teacher experience (which appears in the same formula). Reference to teacher age will occur in the same places as references to teacher experience. The weighting coefficient will be the same, the statement in the sub-routine which uses the variable will be the same, the call to the READ sub-routine to read teacher age should occur immediately before or after the call to the READ subroutine to input teachers experience, and the teacher age file should have the same format as the teacher experience file.

Chapter III describes the theoretical structure of the model. The decision on which variable to add and where to include it can be made referring to that section. The file format can be found in Appendix D, and the steps involved in making the change are found in this appendix.

APPENDIX D

PROGRAM ORGANIZATION

This appendix will give detailed information on program structure, overall flow, sub-routines and data files. The detail will be such that the user who is studying or changing the program itself can use this appendix as a reference.

Program Structure

The program is written in the FORTRAN language of the General Electric, Model 235 time sharing system, and programmed to run on that system. The system is characterized by the relatively small amount of core storage available to the user (approximately 5000 words), by a disc oriented file system, and by a teletype unit used for input/output. These features dictated the program structure. The program is characterized by a large number of indexed variables, parameters, and constants, far too many to fit into the restricted core. In fact, the total program, excluding the variables, parameters, and constants, is too large to fit into the core. This serious core storage constraint forced the use of a hierarchical storage arrangement for data, and "chaining" for the programs.

The next section, Program Flow, presents a flow chart of the program. The set of routines enclosed by the [illegible] at the same time. The set forms a logical unit for running, since the calling sequence among them are iterative, i.e., they are each called a number of times. The programs which are outside the set are called only once each, and are therefore natural candidates for chaining. (The chaining process empties the core of the resident program, and calls in the program chained to. The latter program is then assembled and run. This process would be very slow for sub-routines which were called a number of times, since it involves a read from disc and a compilation each time.)

There is too much data to all reside in core at the same time as the programs. The solution to this problem involved making use of the natural cycle of the MAIN Program. The program loops through its calculation once for each grade and student type. The variables and parameters were stored

in files, each having its own file. The files were broken into units (lines) of grade and student type. At the start of each loop, the program reads the line associated with the grade and student type of that particular loop, for every variable. In this manner, a large amount of file manipulation is the price paid for the limited core storage. The storage is treated hierarchically with the core as high level storage, and the disc a low level storage.

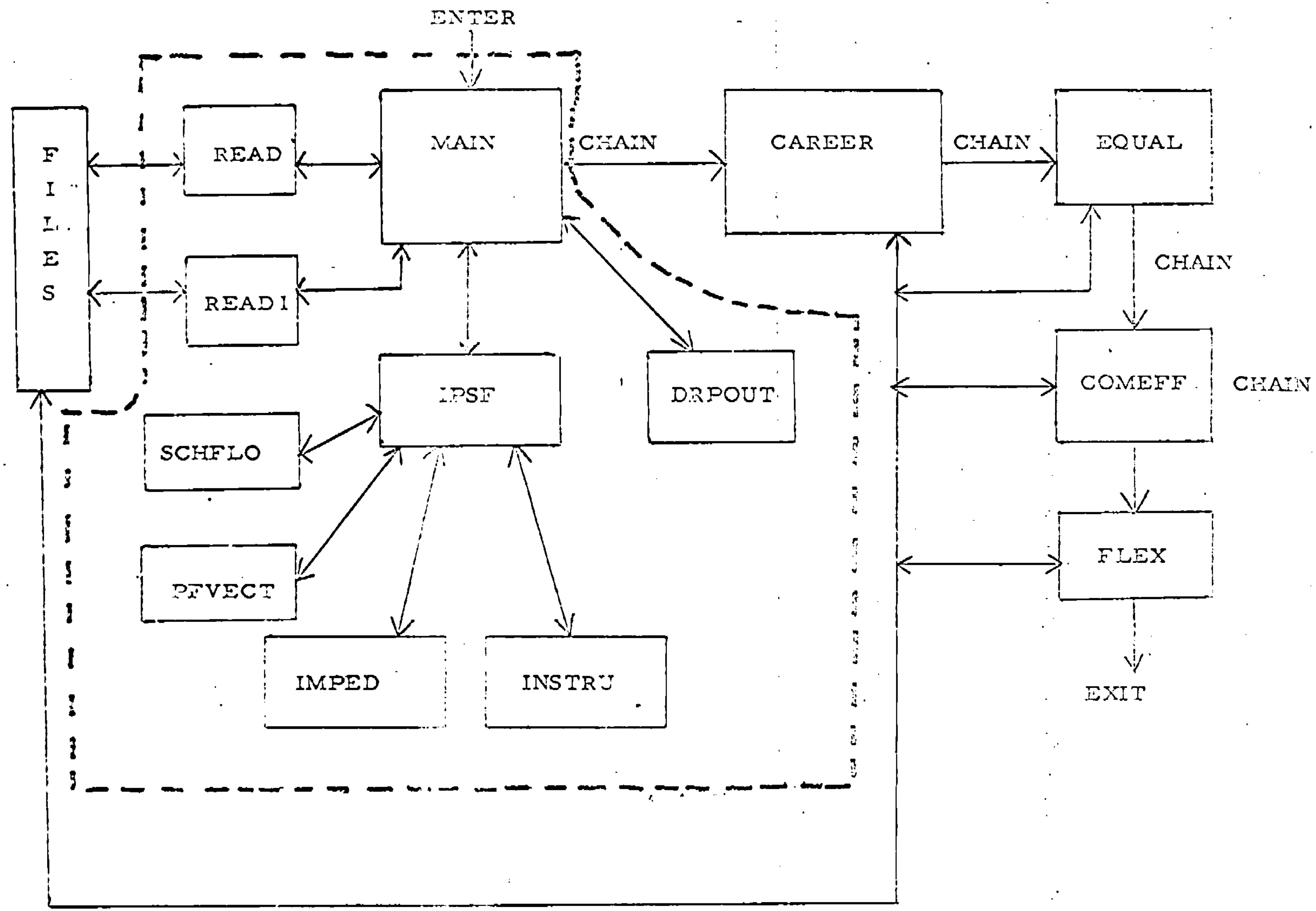


Figure D-1
Program Flow

Program Files

MAIN------The main program; handles the strategic aspects of the run

READ---- I/Ø routine; reads a line of data for a given student (Vector) type and grade from a given file.

READ 1--- I/Ø routine; reads a group of lines of data (matrix) for a given student type and grade from a given file.

IPSF------A major subroutine which projects a student type from one grade to the next, apply in the normal school flow and the intervention processes.

SCHFLØ---The school flow routine; calculates the normal student transitions from one grade to the next using the Markov process

IMPED----Computes the index of impedance

INSTRU----Computes the index of instruction

PFVECT---Provides the connecting calculations between the school flow and intervention processes.

DRPØUT---Computes the numbers of dropouts and truancies for each student type and grade.

CAREER---Estimates the numbers of students expected in each career category in the future based on their school performance.

EQUAL--- Computes the equality of educational opportunity

CØMEFF---Computes expected lifeti[illegible] earnings based on CAREER output.

FLEX-----Prints final output.

Data Files

The data files of the model can be divided into six categories. They are files containing:

1) Student characteristics
2) School characteristics
3) Compensatory Program Characteristics
4) Weighting factors
5) Intermediate results
6) Output variables

The data files used by the program are described below:

Files whose data are a function of student type and grade (actually, a grade index is used; if the set of grades in which achievement tests are given has elements 1, 3, 5, 6, 8, 10 the grade indices are 1, 2, 3, 4, 5, 6; the grade index always ranges from 1 to the number of grades tested.) are arranged so that at least one line corresponds to a particular student type and grade index. Each line contains integers specifying its student type and grade index. If a variable is a function of one but not the other, then the integer in the position of the unrelated quantity is set to zero. For example,

1020 3 6 0.59 0.85

describes variables pertainint to student type 3, grade index 6,

1050 4 0 0.36 0.15

contains a variable for student type 4, but which is not a function of grade index. In general, the sequence is (the lower line is the FORTRAN format)

Line Number		Student Type	Grade Index	N Variables
I4,	1x,	I1,	I2,	NF 6.2 or NI

Student Characteristic File

File	Description	Format
LAST 1	Numbers of students in the grade before the Title I Program, (by student type) average	I4, 2I2, I4
INGLEV	The average achievement levels in the grade before the Title I Program (by student type and test category)	I4, 2I2, 2F6.3

File	Description	Format
STATIN	The average achievement rates in the grade before the Title I Program (by student type and test category)	I4, 2I2, 2F6.3
PPINIT	The percentages of students in the above-below threshhold categories in the following order (b=below, a = above) (bb, ba, ab, aa) (by student type)	I4, 2I2, 4F6.3
DIS	The percentages of students who have each of the six factors of disadvantage (by student type, by six)	I4, 2I2, 6F6.3

School Characteristics Files

File	Description	Format
INIT	Number of grades, number of student types, grade index of initial Title I application, grades (years and month) of achievement tests.	GE Free Format
B1, B2	Regression coefficients relating achievement lag to dropout rates Rate = $1/100 \cdot (B_1 \cdot \text{Lag} + B_2)$ (by grade index)	I4, 2I2, Ix, F6.3
C1, C2	Regression coefficients relating achievement lag to truancies rates Rate = $1/100 (C_1 \text{ Lag} + C_2)$ (by grade index)	"
MARKOV	Markov transition matrix presenting transition probabilities among states of being below (b) and above (a) a threshhold in test categories. (by grade index) For two test categories, the matrix is organized as follows, in the direction from-to (e.g., bb-ba is from below-below to below-above)	

$$\begin{pmatrix} \text{bb-bb} & \text{bb-ba} & \text{bb-ab} & \text{bb-aa} \\ \text{ba-bb} & \text{ba-ba} & \text{ba-ab} & \text{ba-aa} \\ \text{ab-bb} & \text{ab-ba} & \text{ab-ab} & \text{ab-aa} \\ \text{aa-bb} & \text{aa-ba} & \text{aa-ab} & \text{aa-aa} \end{pmatrix}$$

Compensatory Program Characteristics Files

File	Description	Format
RECEN	Recency of curriculum material (Student type, by grade index, by test category)	I4, 2I2, Ix, 2F6. 3
TCHEXP	Teacher experience index (by student type, by grade, by test category)	
TCHRS	Pupil/Teacher Ratio (by student type, by grade index, by test category	"
TEXTS	Textbook/Pupil Ratio (by student type, by grade index by test category)	"
DESKS	Desk/Pupil Ratio (by student type, by grade index, by test category)	"
TCHBUD	Instructional Budget (by student type, by grade index, by test category)	"
TCHDYS	Days/week of instruction (by student type, by grade index, by test category)	"
TCHWKS	Weeks/year of instruction (by student type, by grade index, by test category)	"
CTHRS	Hours/day of instruction (by student type, by grade index, by test category)	I4, 2I2, Ix, 2F6. 3
SRVICS	The number of services (by student type, by grade index)	I4, 2I2, I4
NEW	Service new or old (by student type, by grade index, by service)	I4, 2I2, nI4 (n - # of services)
PARA	Number of paraprofessionals for service (by student type, by grade index, by service)	I4, 2I2, Ix, nF6. 3

File	Description	Format
SPACE	Space/pupil for service (by student, by grade index, by service)	I4, 2I2, IX, nF6. 3
SBUDGT	Service budget (by student types, by grade index, by service)	I4, 2I2, IX, nF6. 3
SHOURS	Hours/day for service (by student type, by grade index, by service)	I4, 2I2, IX, nF6. 3
SDAYS	Days/week for service (by student type, by grade index, by service)	I4, 2I2, IX, nF6. 3
SWEEKS	Weeks/year for service (by student type, by grade index, by service)	I4, 2I2, IX, nF6. 3

Weighting Factor Files

File	Description	Format
SQW	Service quality weights (dimension 2)	I5, 1X, 2F6. 3
SIW	Service intensity weights (dimension 3)	I5, 1X, 3F6. 3
SPW	Service project weights (dimension 3)	I5, IX, 3F6. 3
SW	Service component weights (dimension 3)	I5, IX, 3F6. 3
ZW	Disadvantage factor weights (dimension 6)	I5, IX, 6F6. 3
TQW	Instructional quality weights (by student type, by grade index by 2, by test category)	I4, I2, I2, 1X, 2F6. 3
TIW	Instructional intensity weights (by student type, by grade index, by 4, by test category)	I4, I2, I2, 1X, 4F6. 3
TW	Instructional index weights (by student type, by grade index, by 3, by test category)	I4, I2, I2, 1X, 3F6. 3

Intermediate Results Files:

File	Description	Format
OLDZ	Impedance value of the baseline case (by student type, by grade index)	I4, I2, I2, .X, F6.3
OLDC	Instruction index value of the baseline case (by student type, by grade index, by test category)	I4, I2, I2, 1X, 2F6.3
OLDSER	Service index value of the baseline case (by student type, by grade index)	I4, I2, I2, 1X, F6.3

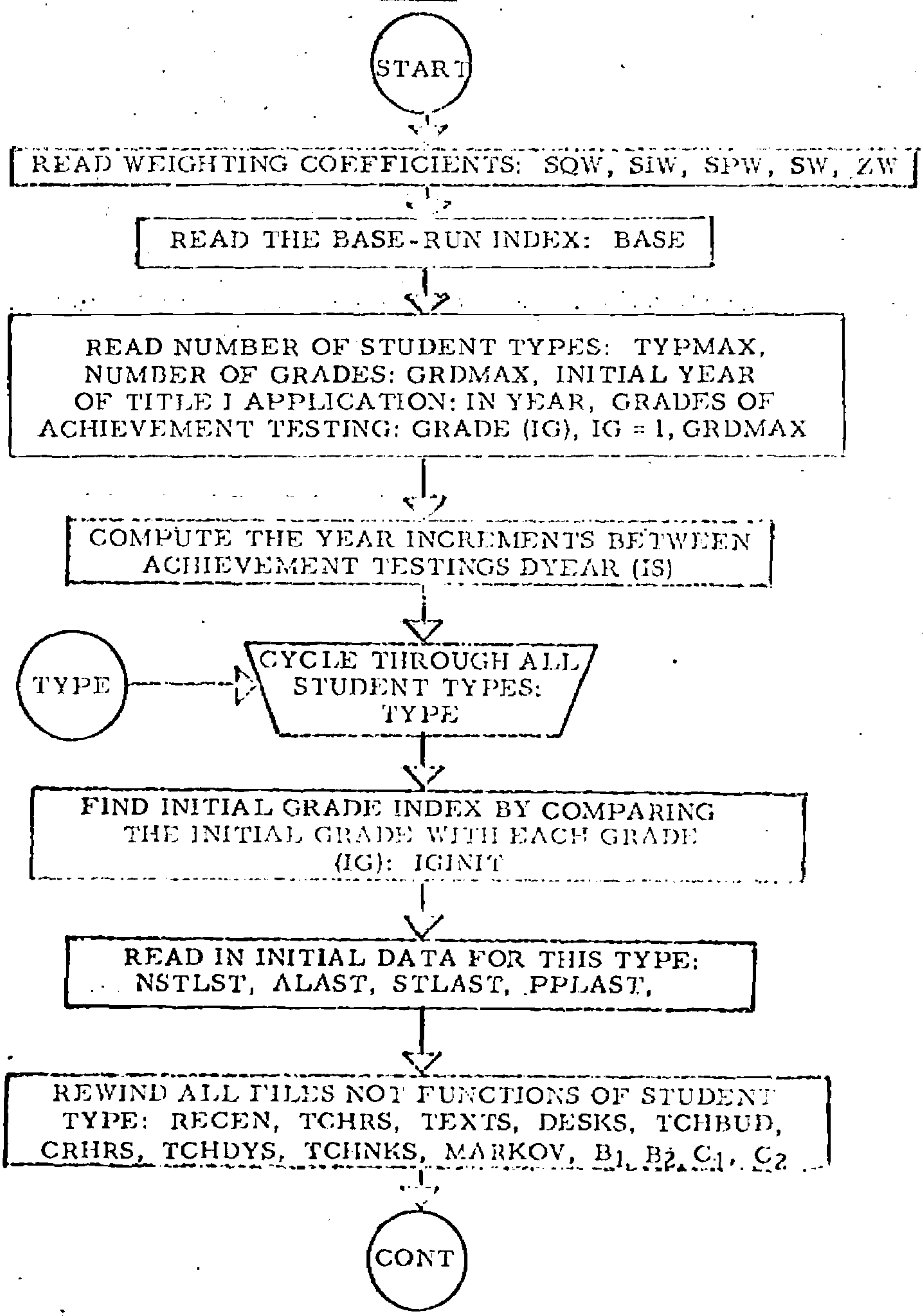
Output Files

File	Description	Format
A	Estimated achievement levels (by student type, by grade index, by test category)	I4, I2, I2, 1X, 2F6.3
DROPS	The numbers of dropouts (by student type, by grade index)	I4, I2, I2, I4
TRUANT	The number of truancies (by student type, by grade index)	I4, I2, I2, I4
NOSTUD	The number of students remaining (by student type, by grade index)	I4, I2, I2, I4
O1	Numbers in each career category potential and expected lifetime earnings for student type 1 (by career category)	Standard Matrix GE FORTRAN
O2	Same for student type 2	"
O3	Same for student type 3	"
O4	Same for student type 4	"

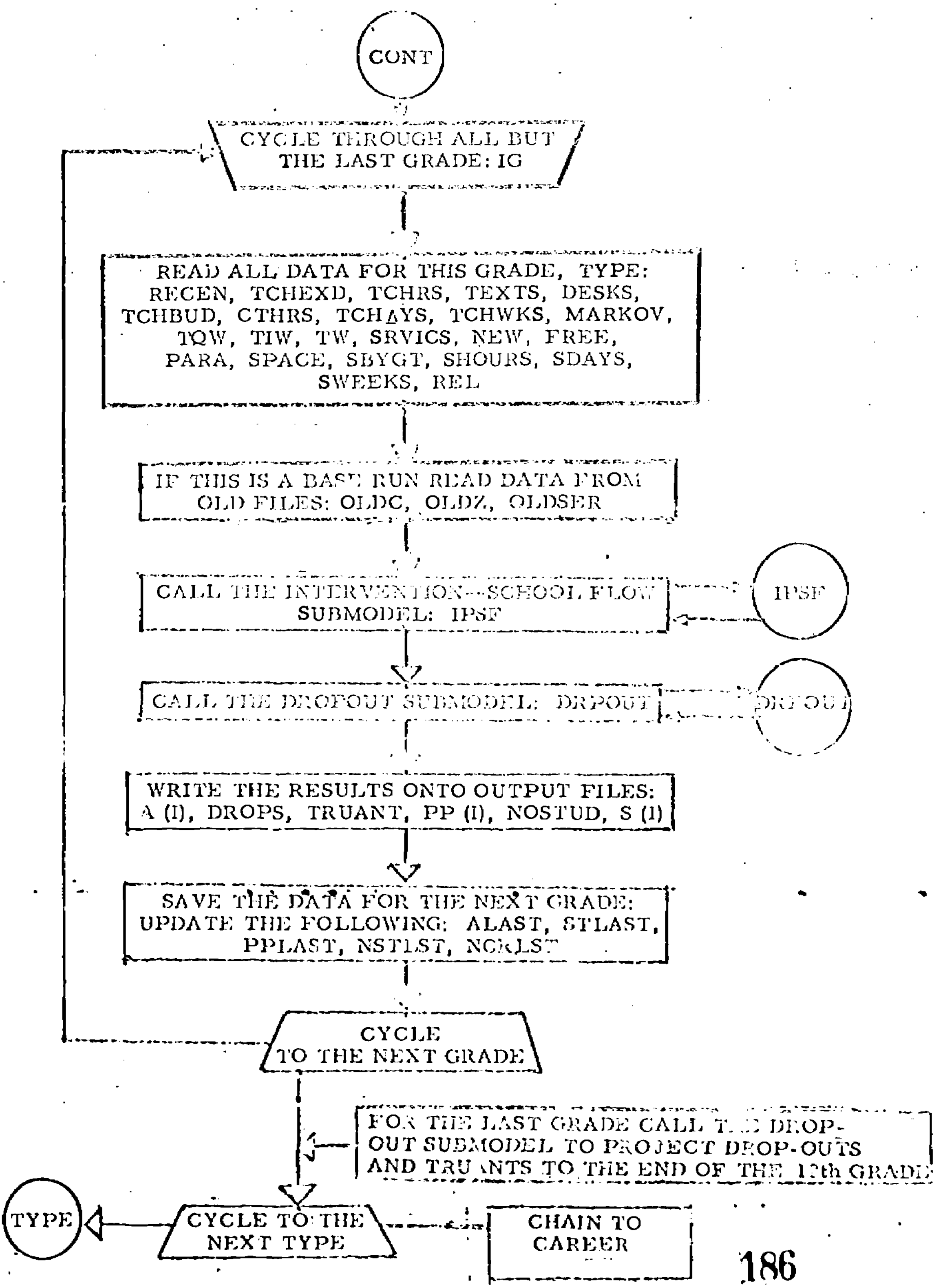
APPENDIX E

FLOW CHARTS

MAIN


START
READ WEIGHTING COEFFICIENTS: SQW, SIW, SPW, SW, ZW
READ THE BASE-RUN INDEX: BASE
READ NUMBER OF STUDENT TYPES: TYPMAX, NUMBER OF GRADES: GRDMAX, INITIAL YEAR OF TITLE I APPLICATION: IN YEAR, GRADES OF ACHIEVEMENT TESTING: GRADE (IG), IG = 1, GRDMAX
COMPUTE THE YEAR INCREMENTS BETWEEN ACHIEVEMENT TESTINGS DYEAR (IS)
TYPE
CYCLE THROUGH ALL STUDENT TYPES: TYPE
FIND INITIAL GRADE INDEX BY COMPARING THE INITIAL GRADE WITH EACH GRADE (IG): IGINIT
READ IN INITIAL DATA FOR THIS TYPE: NSTLST, ALAST, STLAST, PPLAST,
REWIND ALL FILES NOT FUNCTIONS OF STUDENT TYPE: RECEN, TCHRS, TEXTS, DESKS, TCHBUD, CRHRS, TCHDYS, TCHNKS, MARKOV, B1, B2, C1, C2
CONT

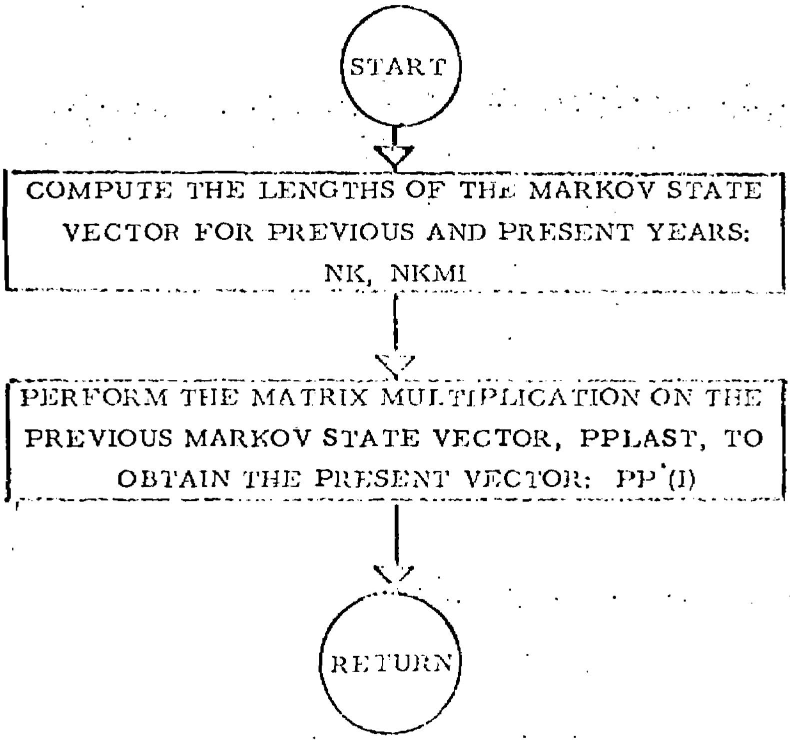
MAIN


CONT
CYCLE THROUGH ALL BUT THE LAST GRADE: IG
READ ALL DATA FOR THIS GRADE, TYPE: RECEN, TCHEXD, TCHRS, TEXTS, DESKS, TCHBUD, CTHRS, TCHDAYS, TCHWKS, MARKOV, TQW, TIW, TW, SRVICS, NEW, FREE, PARA, SPACE, SBYGT, SHOURS, SDAYS, SWEEKS, REL
IF THIS IS A BASE RUN READ DATA FROM OLD FILES: OLDC, OLDZ, OLDSER
CALL THE INTERVENTION--SCHOOL FLOW SUBMODEL: IPSF
IPSF
CALL THE DROPOUT SUBMODEL: DRPOUT
DRPOUT
WRITE THE RESULTS ONTO OUTPUT FILES: A (I), DROPS, TRUANT, PP (I), NOSTUD, S (I)
SAVE THE DATA FOR THE NEXT GRADE: UPDATE THE FOLLOWING: ALAST, STLAST, PPLAST, NSTLST, NGRLST
CYCLE TO THE NEXT GRADE
FOR THE LAST GRADE CALL THE DROP-OUT SUBMODEL TO PROJECT DROP-OUTS AND TRUANTS TO THE END OF THE 12th GRADE
TYPE
CYCLE TO THE NEXT TYPE
CHAIN TO CAREER

186

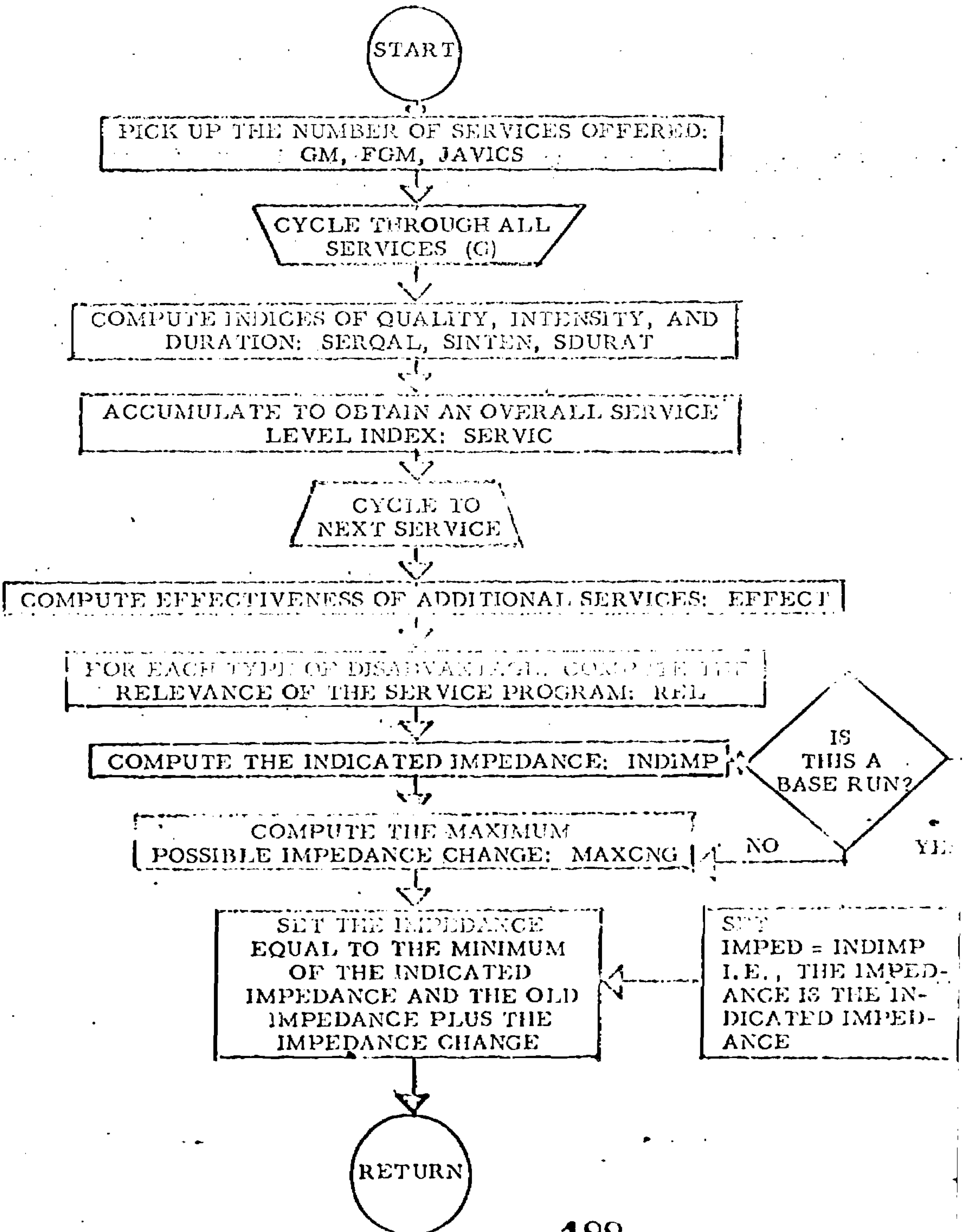
Applies the Markov process to transform the Markov state of one grade group to that of the following grade group.

SCHFLO



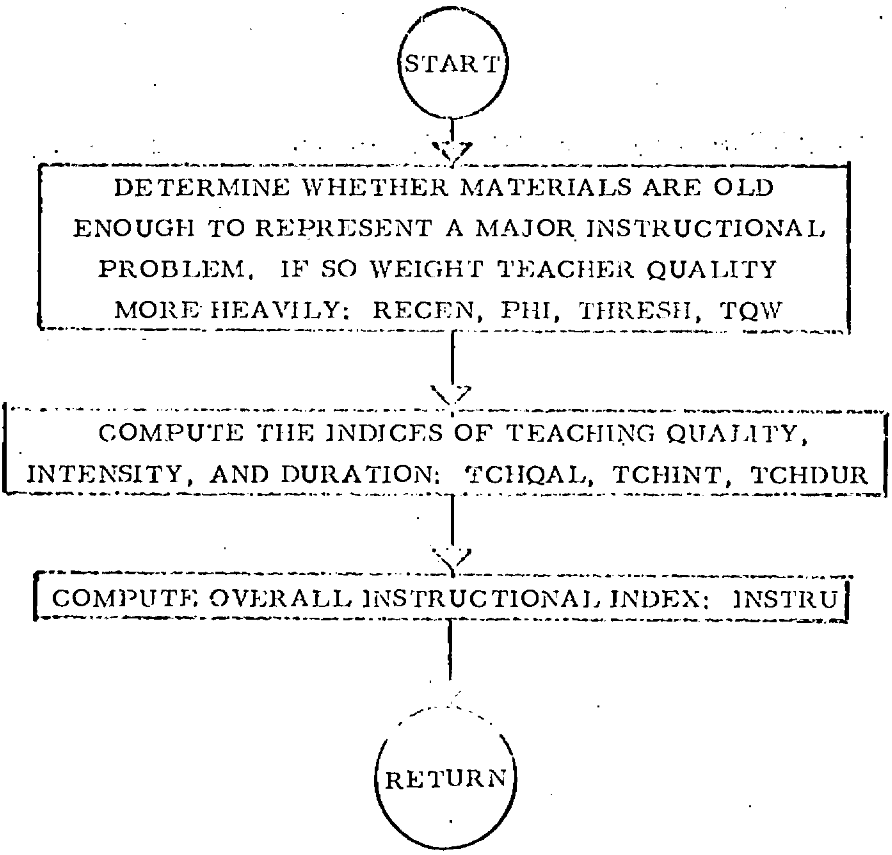
Computes an index of the student population impedance to learning.

IMPED



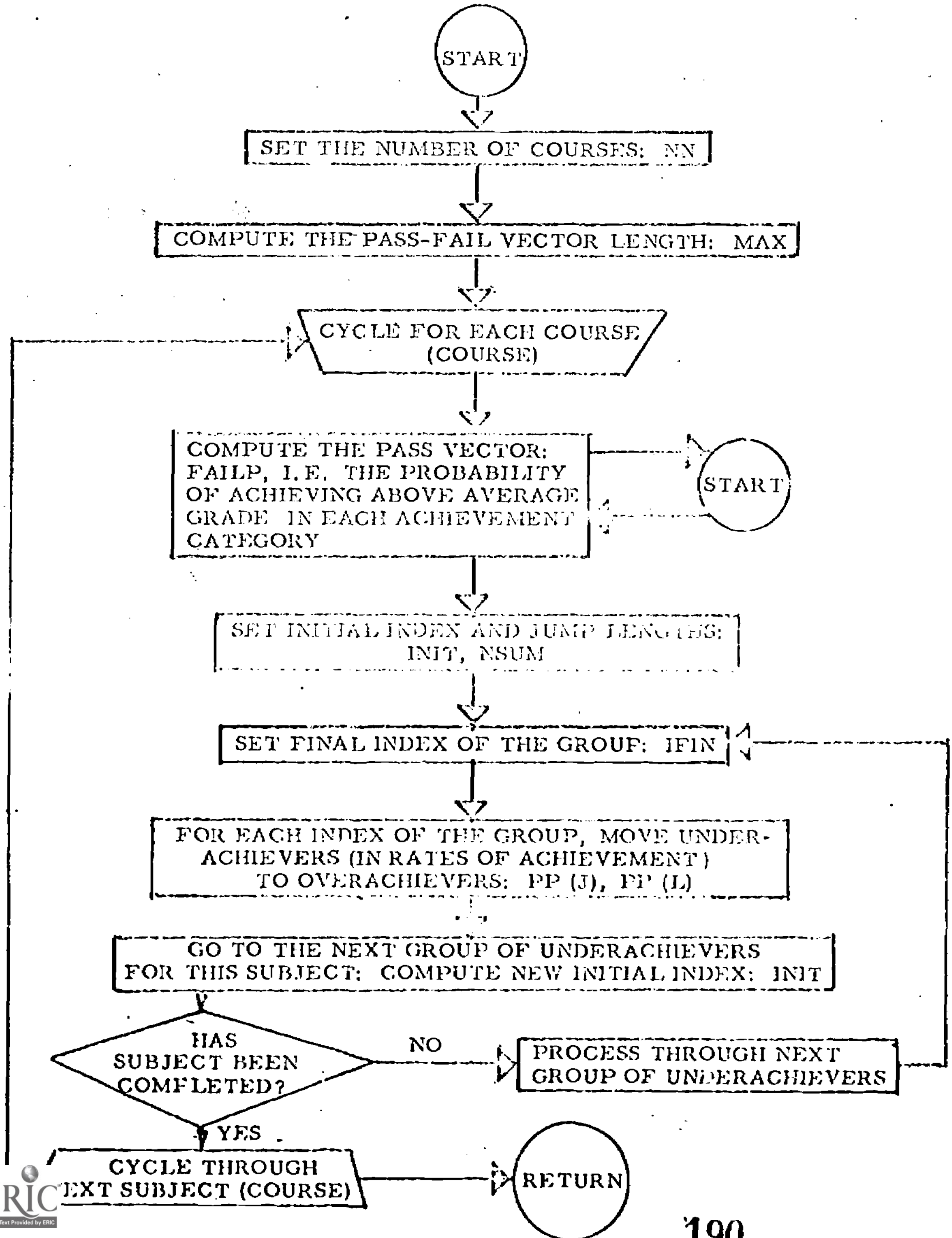
Computes an index of the worth of the instruction being offered by the school.

INSTRU

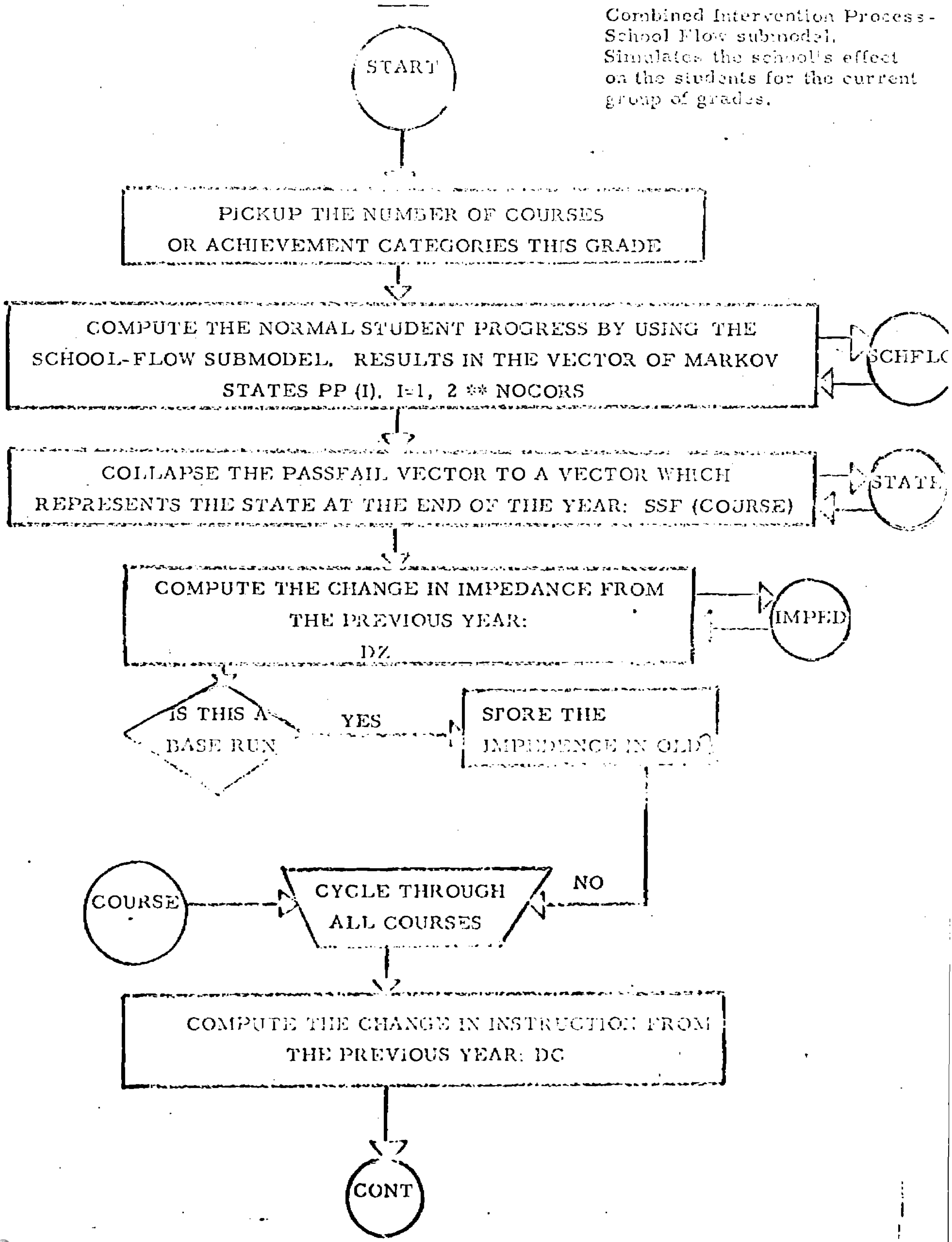


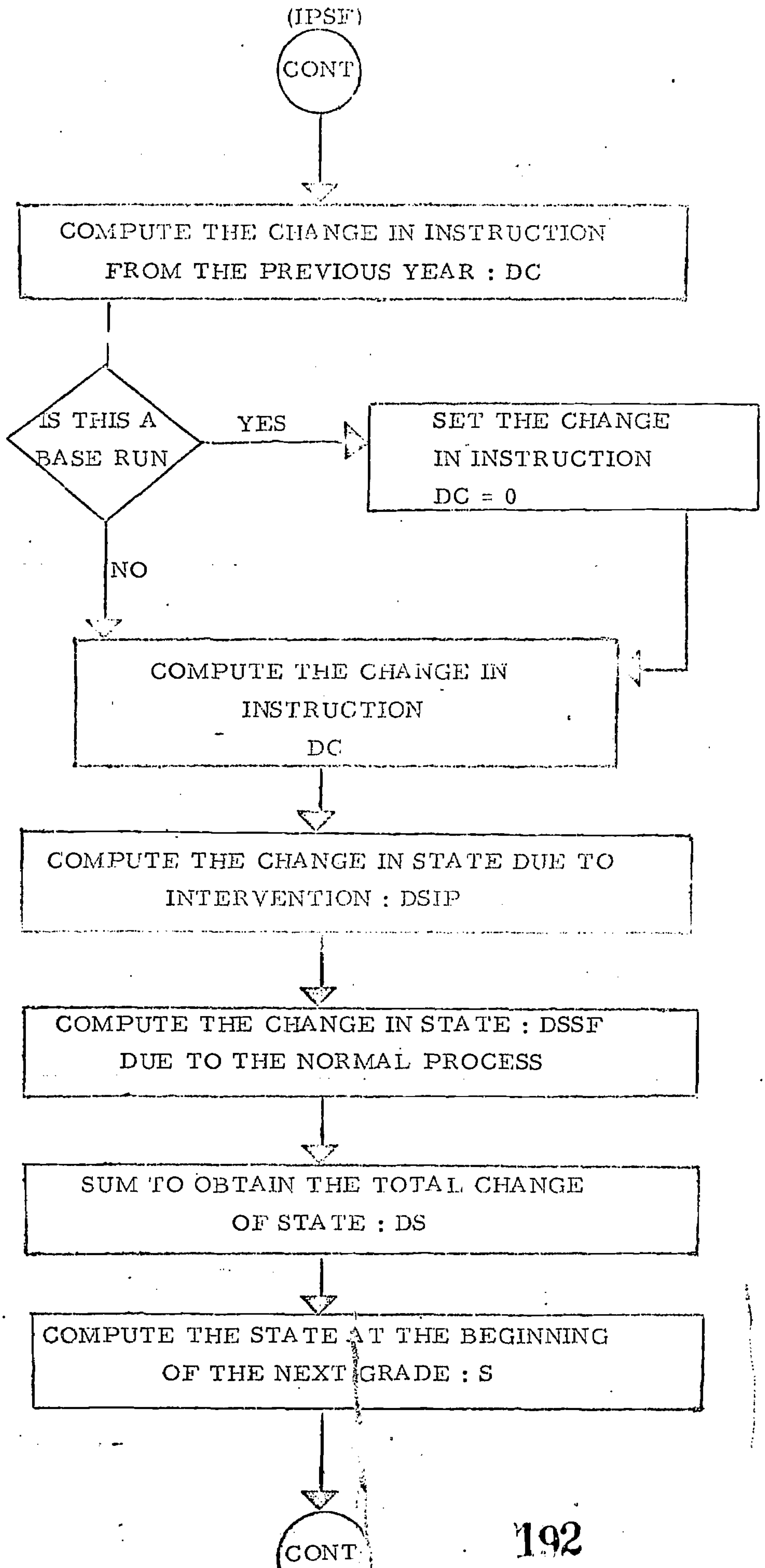
Computes the new achievement rates given an increment due to the Intervention Process and moves the population into its new states.

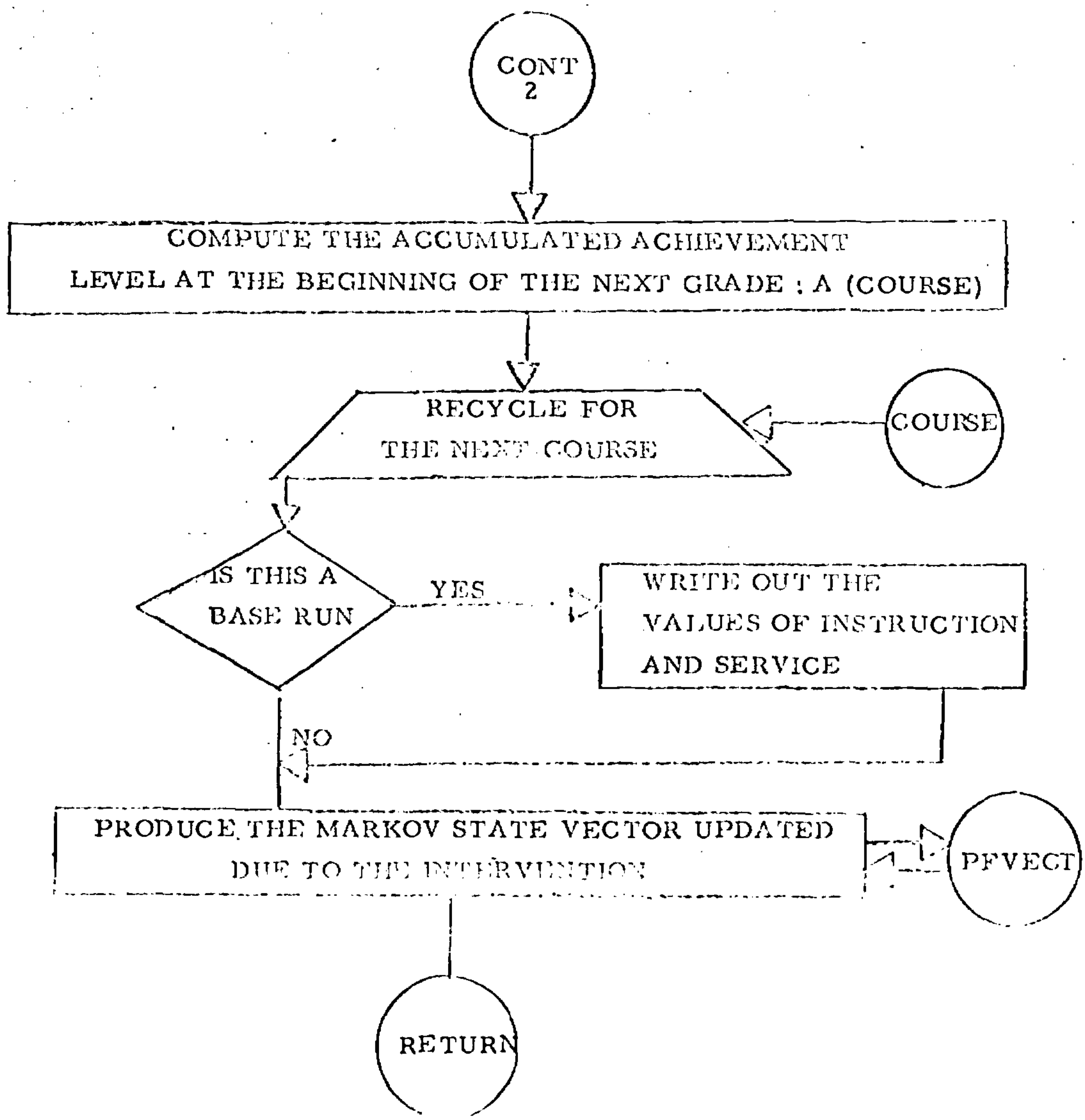
PFVECT



Combined Intervention Process - School Flow submodel. Simulates the school's effect on the students for the current group of grades.



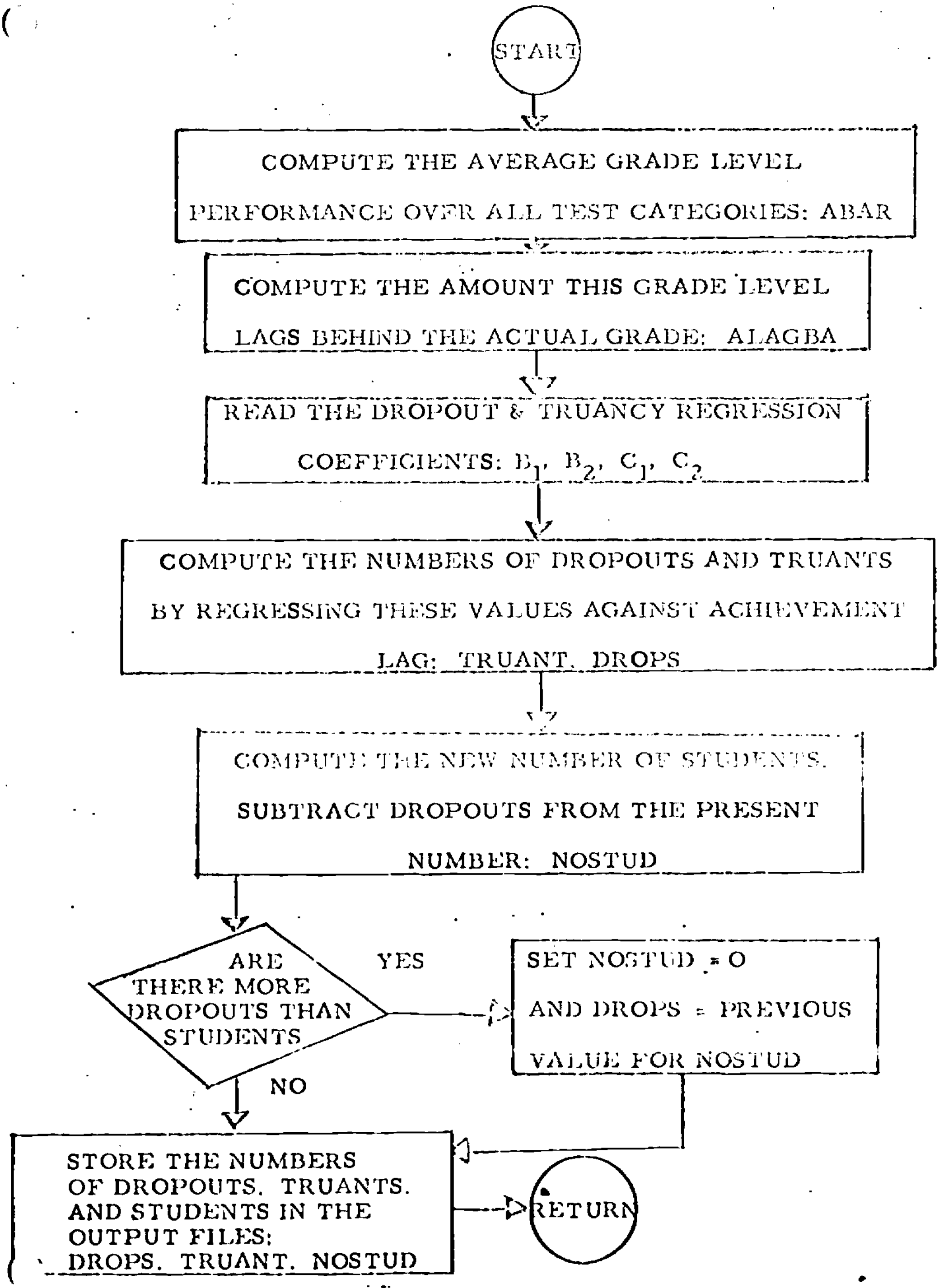

(IPSF)
CONT
COMPUTE THE CHANGE IN INSTRUCTION FROM THE PREVIOUS YEAR : DC
IS THIS A BASE RUN
YES
SET THE CHANGE IN INSTRUCTION DC = 0
NO
COMPUTE THE CHANGE IN INSTRUCTION DC
COMPUTE THE CHANGE IN STATE DUE TO INTERVENTION : DSIP
COMPUTE THE CHANGE IN STATE : DSSF DUE TO THE NORMAL PROCESS
SUM TO OBTAIN THE TOTAL CHANGE OF STATE : DS
COMPUTE THE STATE AT THE BEGINNING OF THE NEXT GRADE : S
CONT



CONT 2
COMPUTE THE ACCUMULATED ACHIEVEMENT LEVEL AT THE BEGINNING OF THE NEXT GRADE : A (COURSE)
RECYCLE FOR THE NEXT COURSE
COURSE
IS THIS A BASE RUN
YES
WRITE OUT THE VALUES OF INSTRUCTION AND SERVICE
NO
PRODUCE THE MARKOV STATE VECTOR UPDATED DUE TO THE INTERVENTION
PFVECT
RETURN

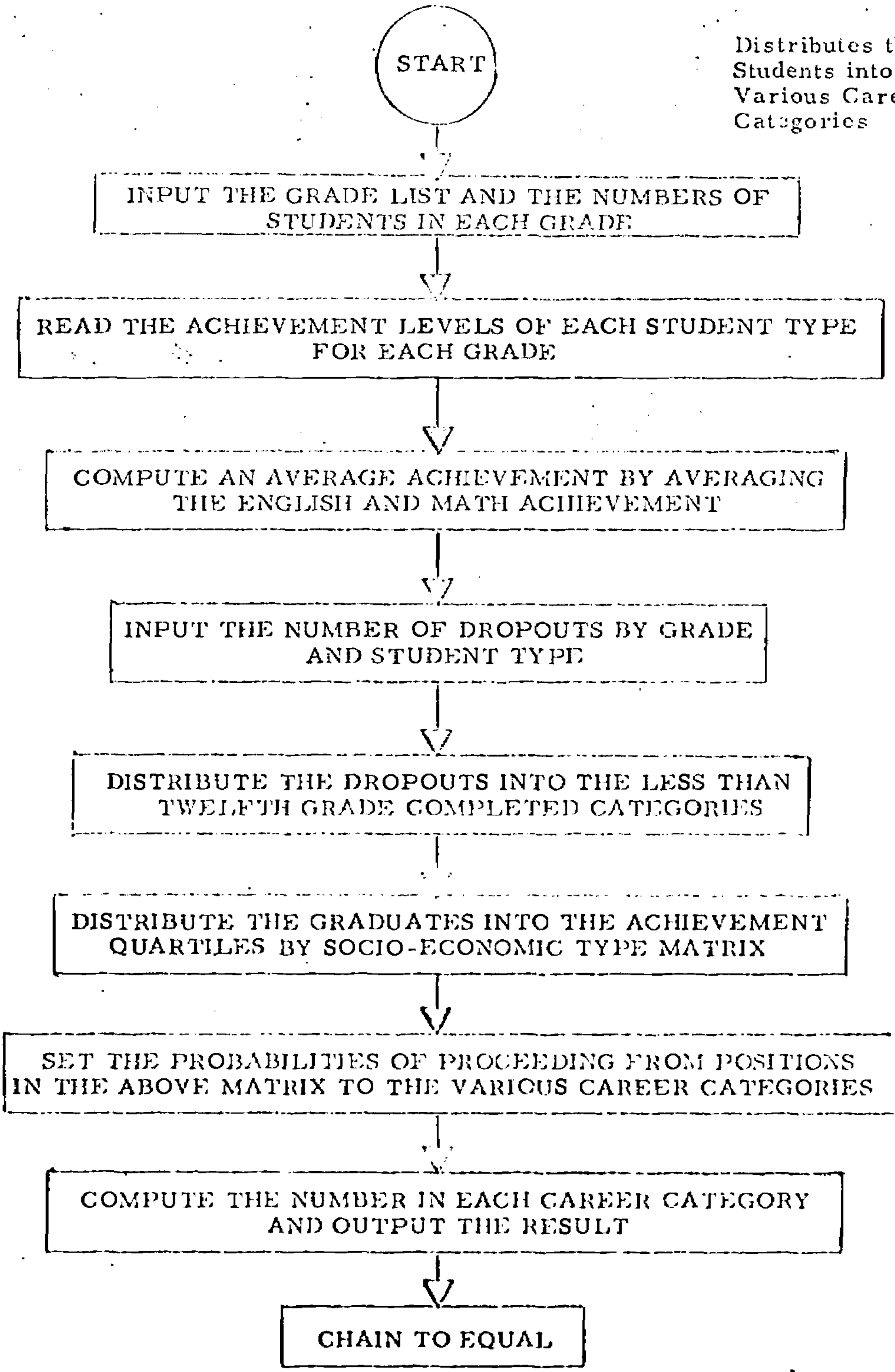
Computes the numbers of dropouts and truancies by regressions of these on achievement lags.

DRPOUT



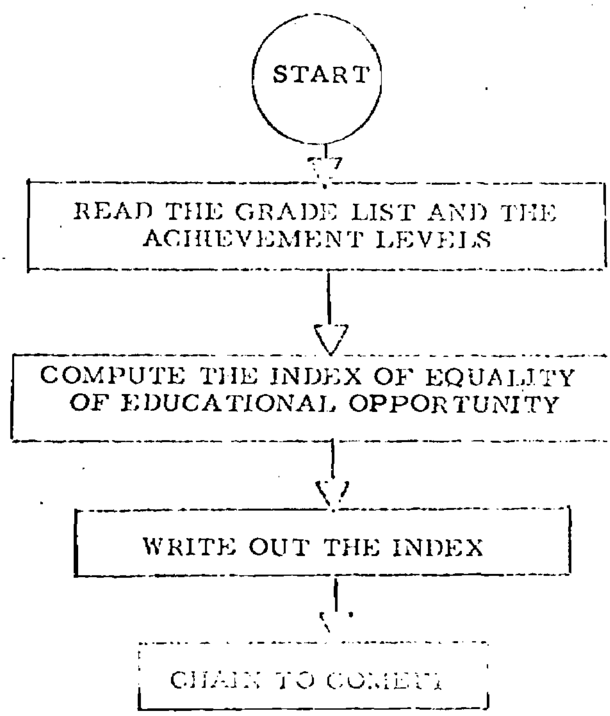
CAREER

Distributes the Students into the Various Career Categories



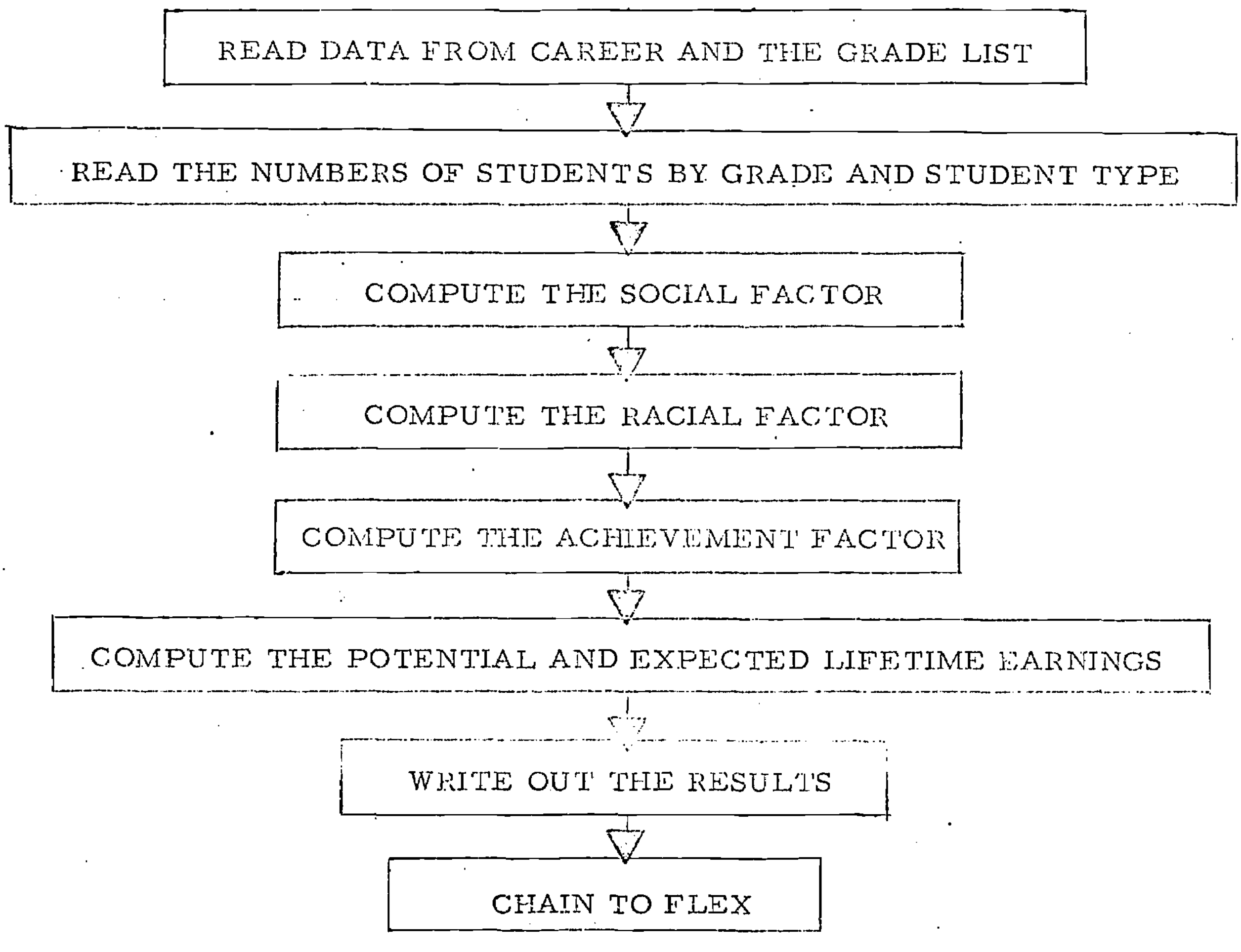
Compute the Index of Equality of Educational Opportunity

EQUAL



Computes the Long-range Community Effects

COMEFF



FLEX

FLEX is the output routine which simply prints the results produced in all of the previous sections.

APPENDIX F

MAIN

```
COM.       USOE COST EFFECTIVENESS MODEL
COM.       MAIN PROGRAM
COM.       FILE STATEMENT FOR THE OEDEV MODEL
           $FILE SQW, SIW, SPW, SW, ZW, INIT, LASTI, INGLEV,
     +     STATIN, PPINIT, NOCORS, RECEN, TCHEMP, TCHRS, TEXTS,
     +     DESKS, TCHBUD, CTHRS, TCHDYS, TCHWKS, MARKOV, TCW,
     +     TIW, TW, SRVICS, NEW, FREE, PARA, SPACE, SBUDGT,
     +     SHOURS, SDAYS, SWEEKS, DIS, B1, B2, C1, C2,
     +     A, DROPS, TRUANT, PP, NOSTUD, STAT, OLDZ, OLDC,
     +     OLDSER,ABAR,REL,X,ANC
           $USE COMMON
           $USE DECLAR
           DIMENSION AA(10),IAA(10)
           INTEGER DROPS,TRUANT
           ZZZ=AB(A(COURSE),1.5,1.0,0)
COM.       READ THE CONSTANTS OF THE MODEL WHICH DONT DEPEND ON
COM.       STUDENT TYPE.
COM.       READ THE VARIOUS WEIGHTING COEFFICIENTS
COM.       SERVICE QUALITY WEIGHTS
           READ(1), (SQW (I), I=1,2)
COM.       SERVICE INTENSITY WEIGHTS
           READ(2),(SIW(I),I=1,3)
COM.       SERVICE PROJECT WEIGHTS
           READ (3), (SPW (I), I=1,3)
COM.       SERVICE WEIGHTS
           READ (4), (SW (I), I = 1,3)
COM.       IMPEDENCE WEIGHTS
           READ (5), (ZW (I), I = 1,[illegible])
COM.       READ [illegible]
           PRINT,"IS THIS A BASE LINE RUN; 1 IF YES, 0 IF NO."
           INPUT,BASE
           PRINT,"         TYPE          GRADE INDEX"
COM.       READ THE NUMBER OF STUDENT TYPES, THE NUMBER OF GRADES
COM.       TO BE EXAMINED, THE INITIAL YEAR OF APPLICATION OF
COM.       THE COMPENSATORY PROGRAM, AND THE TRANSITION GRADES.
           READ(6),GRDMAX,TYPMAX,INYEAR,(GRADE(I),I=1,GRDMAX)
COM.       COMPUTE THE YEAR INCREMENT VECTOR.
           J = GRDMAX - 1
           DO 100, I=1,J
           DYEAR (I) = GRADE(I+1) - GRADE (I)
      100  CONTINUE
COM.       START MAIN LOOP
COM.       CYCLE THRU ALL STUDENT TYPES
           DO 160, TYPE = 1,TYPMAX
COM.       FIND THE INITIAL GRADE INDEX
           DO 110, I=1,GRDMAX
           IF (GRADE(I)-INYEAR) 1,1,110
        1  IGINIT=I
      110  CONTINUE
COM.       READ IN THE INITIAL DATA FOR THIS STUDENT TYPE.
```

MAIN CONTINUED

```
      IG = 0
      CALL READ(7,1,1,AA,NSTLST)
      CALL READ(8,0,2,ALAST,IAA)
      CALL READ(9,0,2,STLAST,IAA)
      CALL READ(10,0,4,PPLAST,IAA)
      CALL READ (34,0,6,DIS,IAA)
COM.  REWIND ALL FILES WHICH ARE NOT FUNCTIONS OF STUDENT TYPE.
COM.  I.E. RECEN,TCHEXP,TCHRS,TEXTS,DESKS,TCHBUD,
COM.  CTHRS, TCHDYS, TCHWKS, MARKOV.
      DO 115,I=12,24
      REWIND I
  115 CONTINUE
COM.  ALSO B1, B2, C1, C2.
      DO 116,I=35,38
      REWIND I
  116 CONTINUE
COM.  CYCLE THROUGH ALL GRADE GROUPS
      IGRD=GRDMAX-1
      DO 159 IG=IGINIT,IGRD
      PRINT,TYPE,IG
COM.  READ ALL DATA FOR THIS GRADE, TYPE.
      CALL READ(12,1,2,AA,RECEN)
      CALL READ(13,0,2,TCHEXP,IAA)
      CALL READ(14,0,2,TCHRS,IAA)
      CALL READ(15,0,2,TEXTS,IAA)
      CALL READ(16,0,2,DESKS,IAA)
      CALL READ(17,0,2,TCHBUD,IAA)
      CALL READ(18,0,2,CTHRS,IAA)
      CALL READ(19,0,2,TCHDYS,IAA)
      CALL READ(20,0,2,TCHWKS,IAA)
      CALL READ1(21,4,4,4,MARKOV)
      CALL READ1(22,2,2,2,TQW)
      CALL READ1(23,4,2,4,TIW)
      CALL READ1(24,3,2,3,TW)
      CALL READ (25,1,1,AA,SRVICS)
      L = SRVICS
      CALL READ (26,1,L,AA,NEW)
      CALL READ (27,1,L,AA,FREE)
      CALL READ (28,0,L,[illegible],IAA)
      CALL READ (29,0,L,SPACE,IAA)
      CALL READ (30,0,L,SBUDGT,IAA)
      CALL READ (31,0,L,SHOURS,IAA)
      CALL READ (32,0,L,SDAYS,IAA)
      CALL READ (33,0,L,SWEEKS,IAA)
      CALL READ(49,1,6,AA,REL)
COM.  IF THIS IS NOT A BASE RUN, READ IN THE OLD FILES.
      IF(BASE)20,20,30
   20 CALL READ (45,0,1,OLDZ,IAA)
      CALL READ(46,0,2,OLDC,IAA)
      CALL READ(47,0,1,OLDSER,IAA)
```

MAIN CONTINUED

```
1990COM.      ALL DATA FILES IN
2000COM.      CALL THE INTERVENTION-SCHOOL FLOW SUBMODELS
2010    30    CALL IPSF
2020COM.      CALL THE DROPOUT SUBMODEL
2030          CALL DRPOUT
2040          ITTRG=1000*TYPE+10*IG
2050COM.      WRITE THE RESULTS ONTO OUTPUT FILES
2060          WRITE(39,800),ITTRG,TYPE,IG,A(1),A(2)
2070          WRITE(42,800),ITTRG,TYPE,IG,(PP(I),I=1,4)
2080          WRITE(44,800),ITTRG,TYPE,IG,S(1),S(2)
2090          WRITE (48,800),ITTRG,TYPE,IG,ABAR
2100   800    FORMAT(I4,1X,I1,1X,I2,10F6.2)
2110COM.      SAVE THE DATA FOR THE NEXT GRADE.
2120          ALAST(1)=A(1)
2130          ALAST(2)=A(2)
2140          STLAST(1)=S(1)
2150          STLAST(2)=S(2)
2160          DO 130,I=1,4
2170          PPLAST(I) = PP(I)
2180   130    CONTINUE
2190          NSTLST = NOSTUD
2200COM.      CYCLE TO THE NEXT GRADE GROUP
2210   150    CONTINUE
2220          IG=GRDMAX
2230          CALL DRPOUT
2240COM.      CYCLE TO THE NEXT TYPE.
2250   160    CONTINUE
2260          ENDFILE 39
2270          ENDFILE [illegible]
2280          ENDFILE 41
2290          ENDFILE 43
2300          PRINT,"REACHED END OF PROGRAM"
2305          $CHAIN CAREER
2310          END
2320          $USE READ
2330          $USE READ1
2340          $USE IPSF
2350          $USE DRPOUT
2360          $OPT SIZE
```

READ

```
1           SUBROUTINE READ(FILENO,FORMNO,DIMEN,AA,IAA)
20COM.      I/O ROUTINE, READS VECTOR QUANTITIES.
30COM.      FILENO - THE FILE'S POSITION IN THE FILE STATEMENT
40COM.      FORMNO - 0=REAL NUMBERS IN THE FILE; 1 =INTEGERS.
50COM.      DIMEN - THE NUMBER OF QUANTITIES IN THE LINE TO BE READ.
60COM.      AA - THE VECTOR TO BE FILLED IF THE VARIABLE IS REAL;
70COM.           OTHERWISE DUMMY
80COM.      IAA - THE VECTOR TO BE FILLED IF THE VARIABLE IS INTEGER;
90COM.           OTHERWISE DUMMY
100         REAL MARKOV
110         INTEGER TRUANT,DROPS
120         INTEGER SRVICS,FREE,RECEN
130         INTEGER REL,BASE,COURSE,TYPE
140         INTEGER TYPMAX,GRDMAX
300         COMMON B1,B2,C1,C2,NOSTUD,TRUANT,INYEAR
310         COMMON NSTLST,DSIP(3),OLDZ,SRVICS,REL(6)
320         COMMON NEW(5),FREE(5),PARA(5),SPACE(5),SBUDGT(5)
330         COMMON SHOURS(5),SDAYS(5),SWEEKS(5),OLDSER,DIS(6)
340         COMMON SQW(2),SIW(5),SPW(5),SW(3),ZW(6),RECEN(3)
350         COMMON TCHEXP(2),TCHRS(2),TEXTS(2),DESKS(2),TCHBUD(2)
360         COMMON CTHRS(2),TCHDYS(2),TCHWKS(2),TQW(2,2),TIW(4,2)
370         COMMON TW(3,2),PP(4),S(3),SSF(3),MARKOV(4,4)
380         COMMON A(2),PPLAST(4),STLAST(3),ALAST(2)
390         COMMON TYPMAX,GRADE(12),DYEAR(12)
400         COMMON SERVIC,BASE,OLDC(2)
410         COMMON DROPS,TYPE,IG,GRDMAX,ABAR
3000        DIMENSION AA(10), IAA(10)
3010        INTEGER FILENO,FORMNO,DIMEN,TYPE1
3020COM.    VECTOR READ ROUTINE
3030COM.    CHECK FOR INTEGER OR FLOATING POINT FORM
3040        IF(FORMNO)21,1,21
3050COM.    FLOATING POINT READ ROUTINE: READS IN DATA ACCORDING TO
3060COM.    DECIMAL FORMAT.
3070COM.    CHECK FOR ENDFILE.
3080      1 IF(ENDFILE FILENO) 3,2
3090      2 PRINT "ENDFILE REACHED -1--REWINDING"
3100        PRINT "FILE NUMBER -- ",FILENO
3110        REWIND FILENO
3120        GO TO 13
3130COM.    READ IN THE TYPE AND GRADE.
3140      3 READ (FILENO, 51) TYPE1, IG1
3150COM.    CHECK IF THE TYPE AND GRADE READ IN MATCH THE TYPE AND
3160COM.    GRADE STORED IN COMMON.  IF THEY MATCH, READ IN THE
3170COM.    DATA VECTOR.  IF NOT, READ IN THE NEXT RECORD.
3180        IF (TYPE1) 5,6,5
3190    5   IF(TYPE1-TYPE)1,6,2
3200    6   IF(IG1)4,15,4
3210      4 IF (IG1-IG) 1,15,2
3220COM.    CHECK FOR ENDFILE A SECOND TIME.
3230     11 IF (ENDFILE FILENO) 13,42
```

READ CONTINUED

```
COM.     READ IN AND CHECK THE TYPE AND GRADE.
      13 READ (FILENO, 51) TYPE1, IG1
         IF(TYPE1)16,17,16
      16 IF(TYPE1-TYPE)11,17,11
     17  IF(IG1)14,15,14
      14 IF (IG1-IG) 11,15,11
COM.     BACKSPACE THE RECORD.
      15 BACKSPACE FILENO
COM.     READ IN THE DATA.
         READ (FILENO, 52),TYPE1,IG1, (AA(I),I=1,DIMEN)
         GO TO 40
COM.     INTEGER READ ROUTINE: READS IN DATA ACCORDING TO INTEGER
COM.     FORMAT SPECIFICATIONS.  EXACTLY PARALLEL PROCEDURE AS
COM.     FOR DECIMAL READ ROUTINE.
      21 IF(ENDFILE FILENO) 23,22
      22 PRINT "ENDFILE REACHED-2--REWINDING"
         PRINT "FILE NUMBER --   ",FILENO
         REWIND FILENO
         GO TO 31
      23 READ(FILENO,51),TYPE1,IG1
         IF(TYPE1)25,26,25
      25 IF(TYPE1-TYPE)21,26,22
     26  IF (IG1)24,35,24
      24 IF (IG1-IG) 21,35,22
      31 IF(ENDFILE FILENO)33,42
      33 READ (FILENO, 51)TYPE1, IG1
         IF(TYPE1)36,37,36
     36  IF(TYPE1-TYPE)31,37,31
     37  IF(IG1)34,35,34
      34 IF (IG1-IG)31,35,31
      35 BACKSPACE FILENO
         READ(FILENO,53),TYPE1,IG1,(IAA(I),I=1,DIMEN)
         GO TO 40
COM.     IF THE VECTOR IS NOT FOUND AFTER A SECOND PASS THROUGH
COM.     THE FILE (WHEN REWIND COMMAND IS REACHED TWICE),
COM.     PRINT OUT AN ERROR MESSAGE AND STOP.
      42 PRINT 800, FILENO, TYPE, IG
     800 FORMAT( "FILE NUMBER", I3,
 +       "HAS NO DATA FOR STUDENT TYPE ",I1,
 +       "GRADE GROUP ",I2)
         STOP
      51 FORMAT (5X, I1, 1X, I2)
      52 FORMAT (5X,I1,1X,I2,10F6.3)
      53 FORMAT (5X,I1,1X,I2,10I5)
      40 RETURN
```

READ1

```
1           SUBROUTINE READ1(FILENO,DIMEN1,DIMEN2,MAXDIM,AA)
20COM.      I/O ROUTINE, READS SQUARE MATRICES
30COM.      FILENO - THE FILE'S POSITION IN THE FILE STATEMENT
40COM.      DIMEN1 - THE ROW DIMENSION TO BE READ
50COM.      DIMEN2 - THE COLUMN DIMENSION TO BE READ
60COM.      MAXDIM - THE DIMENSION OF THE STORAGE MATRIX
70COM.      AA - THE MATRIX
100         REAL MARKOV
110         INTEGER TRUANT,DROPS
120         INTEGER SRVICS,FREE,RECEN
130         INTEGER REL,BASE,COURSE,TYPE
140         INTEGER TYPMAX,GRDMAX
300         COMMON B1,B2,C1,C2,NOSTUD,TRUANT,INYEAR
310         COMMON NSTLST,DSIP(3),OLDZ,SRVICS,REL(6)
320         COMMON NEW(5),FREE(5),PARA(5),SPACE(5),SBUDGT(5)
330         COMMON SHOURS(5),SDAYS(5),SWEEKS(5),OLDSER,DIS(6)
340         COMMON SQW(3),STW(5),SPW(3),SJ(5),ZW(6),RECEN(3)
350         COMMON TCHEXP(2),TCHRS(2),TEXTS(2),DESKS(2),TCHBUD(2)
360         COMMON CTHRS(2),TCHDYS(2),TCHWKS(2),TQW(2,2),TIW(4,2)
370         COMMON TW(3,2),PP(4),S(3),SSF(3),MARKOV(4,4)
380         COMMON A(2),PPLAST(4),STLAST(3),ALAST(2)
390         COMMON TYPMAX,GRADE(12),DYEAR(12)
400         COMMON SERVIC,BASE,OLDC(2)
410         COMMON DROPS,TYPE,IG,GRDMAX,ABAR
4000        DIMENSION AA(64)
4010COM.    MATRIX READ ROUTINE
4020        INTEGER FILENO,DIMEN1,DIMEN2,TYPE1
4030COM.    SET REWIND INDICATOR FLAG.
4040        JJ=1
4050      1 I=1
4060COM.    CHECK FOR END OF FILE.
4070        IF(ENDFILE FILENO)3,2
4080      2 GOTO (11,12), JJ
4090COM.    READ IN THE TYPE AND GRADE.
4100      3 READ (FILENO, 51) TYPE1, IG1
4110COM.    CHECK IF THE TYPE AND GRADE READ IN MATCH THE
4120COM.    TYPE AND GRADE STORED IN COMMON.
4130        IF(TYPE1)15,15,15
4140     15 IF(TYPE1-TYPE)1,16,2
4150     16 IF(IG1)4,21,4
4160      4 IF (IG1-IG) 1,21,2
4170COM.    IF TYPE AND GRADE MATCH THOSE IN COMMON, BACKSPACE AND
4180COM.    READ IN THE FIRST ROW VECTOR.
4190     21 BACKSPACE FILENO
4200        READ (FILENO,52),(AA(I),I=1,DIMEN1)
4210        IF(DIMEN2-1)25,13,25.
4220   25   CONTINUE
4230COM.    READ IN THE OTHER ROW VECTORS, CHECKING FOR TYPE AND GRADE.
4240        DO 9, II=2,DIMEN2
4250      6 IF(ENDFILE FILENO)7,2
```

READ1 CONTINUED

```
4260      7 READ (FILENO, 51) TYPE1, IG1
4270        IF(TYPE1)17,18,17
4280     17 IF(TYPE1-TYPE)6,18,6
4290     18 IF(IG1)8,22,8
4300      8 IF (IG1-IG) 6,22,6
4310     22 BACKSPACE FILENO
4320COM.    SET THE VALUE OF THE MATRIX INDICES.
4330        N1=MAXDIM*(II-1)+1
4340        N2=N1+DIMEN1-1
4350        READ (FILENO, 52), (AA(I), I=N1,N2)
4360      9 CONTINUE
4370        GO TO 13
4380     11 PRINT "ENDFILE ENCOUNTERED--REWINDING"
4390        PRINT "FILE NUMBER", FILENO
4400        REWIND FILENO
4410COM.    INCREMENT THE REWIND INDICATOR FLAG.
4420        JJ=2
4430        GO TO 1
4440COM.    IF MATRIX IS NOT FOUND, PRINT ERROR MESSAGE AND STOP.
4450     12 PRINT 8000, FILENO, TYPE, IG
4460   8000 FORMAT(" FILE NUMBER",I3,
4470   +    " HAS NO MATRIX OF SIZE SPECIFIED ",/,
4480   +    " FOR STUDENT TYPE ",I1," GRADE GROUP ",I2)
4490        STOP
4500     51 FORMAT (5X, I1, 1X, I2)
4510     52 FORMAT(8X,10F6.3)
4520     13 RETURN
```

IPSF

```
1           SUBROUTINE IPSF
20COM.      PROJECTS THE STUDENTS ACHIEVEMENTS FOWARD IN TIME
30COM.      COMBINING THE NORMAL SCHOOL FLOW AND THE INTERVENTION
40COM.      PROCESSES
100         REAL MARKOV
110         INTEGER TRUANT,DROPS
120         INTEGER SRVICS,FREE,REGEN
130         INTEGER REL,BASE,COURSE,TYPE
140         INTEGER TYPMAX,GRDMAX
300         COMMON B1,B2,C1,C2,NOSTUD,TRUANT,INYEAR
310         COMMON NSTLST,DSIP(3),OLDZ,SRVICS,REL(6)
320         COMMON NEW(5),FREE(5),PARA(5),SPACE(5),SBUDGT(5)
330         COMMON SHOURS(5),SDAYS(5),SWEEKS(5),OLDSER,DIS(6)
```

IPSF CONTINUED

```
          COMMON SQW(2),SIW(5),SPW(5),SW(3),ZW(6),RECEN(3)
          COMMON TCHEXP(2),TCHRS(2),TEXTS(2),DESKS(2),TCHBUD(2)
          COMMON CTHRS(2),TCHDYS(2),TCHWKS(2),TQW(2,2),TIW(4,2)
          COMMON TW(3,2),PP(4),S(3),SSF(3),MARKOV(4,4)
          COMMON A(2),PPLAST(4),STLAST(3),ALAST(2)
          COMMON TYPMAX,GRADE(12),DYEAR(12)
          COMMON SERVIC,BASE,OLDC(2)
          COMMON DROPS,TYPE,IG,GRDMAX,ABAR

          DIMENSION C(3)
          ITTRG=1000*TYPE+10*IG
COM.      COMPUTE THE PASS-FAIL PROBABILITY VECTOR PP
          CALL SCHFLO
COM.      COLLAPSE THE PP VECTOR TO A VECTOR SSF (COURSE)
COM.      WHICH REPRESENTS THE STATE AT THE END OF THE YEAR
          SSF(1)=PP(2)+PP(4)
          SSF(2)=PP(3)+PP(4)
COM.      COMPUTE THE IMPEDANCE AND THE CHANGE FROM THE PREVIOUS
COM.      YEAR
          CALL IMPED(Z)
COM.      IF THIS IS A BASE RUN, WRITE THE VALUE OF Z AND SET DZ=0
          IF(BASE)14,14,13
     13   WRITE (45,800),ITTRG,TYPE,IG,Z
    800   FORMAT (I4,1X,I1,1X,I2,10F6.3)
          DZ=0.0
          GOTO16
     14   DZ=Z-OLDZ
COM.      FOR EACH COURSE, COMPUTE THE LEVEL OF INSTRUCTION AND
COM.      THE CHANGE FROM THE PREVIOUS YEAR
     16   DO 120,COURSE=1,2
          CALL INSTRU(COURSE,CC)
          C(COURSE)=CC
COM.      IF THIS IS A BASE RUN, SET DC=0
          IF(BASE)15,15,17
     17   DC=0.0
          GOTO20
     15   DC = C (COURSE) - OLDC (COURSE)
COM.      COMPUTE CHANGE IN STATE DUE TO INTERVENTION
     20   DSIP(COURSE)=(1.0/Z)*(DC+(C(COURSE)/Z)*DZ)*
     +    (((GRADE(IG)-ALAST(COURSE))/DYEAR(IG))-STLAST(COURSE))
COM.      COMPUTE THE CHANGE IN STATE
          DSSF = SSF (COURSE) -STLAST (COURSE)
COM.      SUM TO OBTAIN TOTAL STATE CHANGE
          DS = DSIP(COURSE) + DSSF
COM.      COMPUTE STATE AT BEGINNING OF NEXT GRADE
          S(COURSE) = STLAST(COURSE) + DS
COM.      COMPUTE ACCUMULATED ACHIEVEMENT LEVEL AT THE BEGINNING OF
COM.      THE NEXT GRADE
          A(COURSE)=ALAST(COURSE)+AB(S(COURSE),1.5,1.0,1)*DYEAR(IG)
COM.      RECYCLE TO NEXT COURSE
```

IPSF CONTINUED

```
      120 CONTINUE
COM.      IF THIS IS A BASE RUN, SAVE THE INSTRUCTION VALUES AND
COM.      THE SERVICE VALUES
          IF(BASE)25,25,22
       22 WRITE (46,800),ITTAG,TYPE,IG,C(1),C(2)
          WRITE (47,800),ITTAG,TYPE,IG,SERVIC
COM.      ESTIMATE PASS-FAIL PROBABILITIES
       25 CALL PFVECT
       75 RETURN
          $USE SCHFLO
          $USE IMPED
          $USE INSTRU
          $USE PFVECT
          FUNCTION AB(FU,SD,YBAR,IFLAG)
          DIMENSION X(85),ANC(85)
          IF (IFLAG) 30,10,30
       10 READ (50) X
          READ (51) ANC
          GO TO 111
       30 DO 100 J=1,85
          DIF=ANC(J)-FU
          IF (DIF) 50,50,90
       50 USTAR=X(J-1)+((FU-ANC(J-1))/(ANC(J)-ANC(J-1)))*(X(J)-
          +X(J-1))
          GO TO 110
       90 DIF=85-J
          IF (DIF) 100,50,100
      100 CONTINUE
      110 XBAR=YBAR+SD*USTAR
      111 AB=XBAR
           RETURN
          END
656585
```

SCHFLO

```
1             SUBROUTINE SCHFLO
20COM.        PERFORMS THE SCHOOL FLOW USING THE MARKOV PROCESS
100           REAL MARKOV
110           INTEGER TRUANT,DROPS
120           INTEGER SRVICS,FREE,RECEN
130           INTEGER REL,BASE,COURSE,TYPE
140           INTEGER TYPMAX,GRDMAX
300           COMMON B1,B2,C1,C2,NOSTUD,TRUANT,INYEAR
310           COMMON NSTLST,DSIP(3),OLDZ,SRVICS,REL(6)
320           COMMON NEW(5),FREE(5),PARA(5),SPACE(5),SBUDGT(5)
330           COMMON SHOURS(5),SDAYS(5),SWEEKS(5),OLDSER,DIS(6)
340           COMMON SQW(2),SJW(5),SPW(5),SW(3),ZW(6),RECEN(3)
350           COMMON TCHEXP(2),TCHRS(2),TEXTS(2),DESKS(2),TCHBUD(2)
360           COMMON CTHRS(2),TCHDYS(2),TCHWKS(2),TQW(2,2),TIW(4,2)
370           COMMON TW(3,2),PP(4),S(3),SSF(3),MARKOV(4,4)
380           COMMON A(2),PPLAST(4),STLAST(3),ALAST(2)
390           COMMON TYPMAX,GRADE(12),DYEAR(12)
400           COMMON SERVIC,BASE,OLDC(2)
410           COMMON DROPS,TYPE,IG,GRDMAX,ABAR
7000COM.      SCHOOL FLOW SUBROUTINE: TRANSFORMS THE PASS-FAIL
7010COM.      VECTOR PREDICTED FOR THE END OF THE LAST GRADE
7020COM.      INTO THE VECTOR FOR THE END OF THE CURRENT GRADE.
7030COM.      DO THE MATRIX MULTIPLICATION.
7040          DO 101,L=1,4
7050          PP (L) = 0.0
7060          DO 100,M=1,4
7070          PP(L) = PP(L) + MARKOV (L,M) * PPLAST(M)
7080    100   CONTINUE
7090    101   CONTINUE
7100    75    RETURN
```

IMPED

```
1             SUBROUTINE IMPED(Z)
20COM.        COMPUTES THE STUDENT IMPEDENCE
30COM.        Z - THE IMPEDENCE
100           REAL MARKOV
110           INTEGER TRUANT,DROPS
120           INTEGER SRVICS,FREE,RECEN
130           INTEGER REL,BASE,COURSE,TYPE
140           INTEGER TYPMAX,GRDMAX
300           COMMON B1,B2,C1,C2,NOSTUD,TRUANT,INYEAR
310           COMMON NSTLST,DSIP(3),OLDZ,SRVICS,REL(6)
```

IMPED CONTINUED

```
          COMMON NEW(5),FREE(5),PARA(5),SPACE(5),SBUDGT(5)
          COMMON SHOURS(5),SDAYS(5),SWEEKS(5),OLDSER,DIS(6)
          COMMON SQW(2),SIW(5),SPW(5),SW(3),ZW(6),RECEN(3)
          COMMON TCHEXP(2),TCHRS(2),TEXTS(2),DESKS(2),TCHBUD(2)
          COMMON CTHRS(2),TCHDYS(2),TCHWKS(2),TQW(2,2),TIW(4,2)
          COMMON TW(3,2),PP(4),S(3),SSF(3),MARKOV(4,4)
          COMMON A(2),PPLAST(4),STLAST(3),ALAST(2)
          COMMON TYPMAX,GRADE(12),DYEAR(12)
          COMMON SERVIC,BASE,OLDC(2)
          COMMON DROPS,TYPE,IG,GRDMAX,ABAR
          DIMENSION SERQAL(5),SINTEN(5),SDURAT(5)
          REAL INDIMP
COM.      PICK UP THE NUMBER OF SERVICES OFFERED
          GM=SRVICS
          FGM=GM
COM.      FOR EACH SERVICE, COMPUTE INDICES OF QUALITY,
COM.      INTENSITY, AND DURATION
          SERVIC=0.0
          DO 110,G=1,GM
          SERQAL(G)=SQW(1)*NEW(G)+SQW(2)*FREE(G)
          SINTEN(G)=SIW(1)*PARA(G)+SIW(2)*SPACE(G)+SIW(3)*SBUDGT(G)
          SDURAT(G)=SHOURS(G)*SDAYS(G)*SWEEKS(G)
COM.      ACCUMULATE TO OBTAIN AN OVERALL SERVICE LEVEL INDEX
          SERVIC=SERVIC+(1.0/FGM)*SPW(G)*
     +    (SW(1)*SERQAL(G)+SW(2)*SINTEN(G)+SW(3)*SDURAT(G))
COM.      RECYCLE TO NEXT SERVICE
     110  CONTINUE
COM.      IF THIS IS A BASE RUN, [illegible] THE CHANGE IN SERVICE AND
COM.      THE [illegible] DUE TO [illegible]
COM.      IF NOT, COMPUTE THE INCREASE OVER THE BASE.
          IF(BASE)7,7,6
     6    SCHANG = 0.0
          EFFECT=0
          GO TO 8
     7    SCHANG=SERVIC-OLDSER
COM.      COMPUTE THE EFFECTIVENESS OF THE ADDITIONAL SERVICES
          EFFECT=SCHANG/(1.0+((GRADE(IG)-DYEAR(IG))/OLDZ)**2)
COM.      COMPUTE THE INDICATED IMPEDANCE
     8    INDIMP=1.0
          DO 12,I=1,6
          INDIMP=INDIMP+(ZW(I)*DIS(I)*(1.0-EFFECT*REL(I)))
     12   CONTINUE
COM.      IF THIS IS A BASE RUN, USE INDIMP AS THE IMPEDANCE.
          IF (BASE)10,10,9
     9    Z=INDIMP
          GOTO75
COM.      COMPUTE THE MAXIMUM POSSIBLE IMPEDANCE CHANGE
     10   MAXCNG=(OLDZ-1.0)/(6.0*(1.0+5.0*(OLDZ/49.0)*(OLDZ/49.0)))
COM.      COMPUTE NEW IMPEDANCE
          Z=MINIF((OLDZ+MAXCNG),INDIMP)
```

IMPFD CONTINUED

```
5460  75    RETURN
```

INSTRU

```
1             SUBROUTINE INSTRU(COURSE,CC)
20COM.        COMPUTES THE INDEX OF INSTRUCTION
30COM.        COURSE - THE TEST CATAGORY
40COM.        CC - THE IMPEDENCE INDEX
100           REAL MARKOV
110           INTEGER TRUANT,DROPS
120           INTEGER SRVICS,FREE,RECEN
130           INTEGER REL,BASE,COURSE,TYPE
140           INTEGER TYPMAX,GRDMAX
300           COMMON B1,B2,C1,C2,POSTUD,TRUANT,DDYEAR
310           COMMON BSTLST,DSIP(5),OLDZ,SRVICS,REL(6)
320           COMMON NEW(5),FREE(5),PARA(5),SPACE(5),SBUDGT(5)
330           COMMON SHOURS(5),SDAYS(5),SWEEKS(5),OLDSER,DIS(6)
340           COMMON SQW(2),SIW(5),SPW(5),SW(3),ZW(6),RECEN(3)
350           COMMON TCHEXP(2),TCHRS(2),TEXTS(2),DESKS(2),TCHBUD(2)
360           COMMON CTHRS(2),TCHDYS(2),TCHWKS(2),TQW(2,2),TIW(4,2)
370           COMMON [illegible]
380           COMMON A(2),[illegible]
390           COMMON TYPMAX,GRADE(12),DYEAR(12)
400           COMMON SERVIC,BASE,OLDC(2)
410           COMMON DROPS,TYPE,IG,GRDMAX,AEAR
9000COM.      COMPUTE INDICES OF TEACHING QUALITY, INTENSITY, AND DURATION
9010    21    TCHQAL=TQW(1,COURSE)*RECEN(COURSE)+
9020    +     TQW(2,COURSE)*TCHEXP(COURSE)
9030          TCHINT=TIW(1,COURSE)*TCHRS(COURSE)+TIW(2,COURSE)*
9040    +     TEXTS(COURSE)+TIW(3,COURSE)*DESKS(COURSE)+
9050    +     TIW(4,COURSE)*TCHBUD(COURSE)
9060          TCHDUR=CTHRS(COURSE)*TCHDYS(COURSE)*TCHWKS(COURSE)
9070COM.      COMPUTE OVERALL INSTRUCTION INDEX
9080          CC=TW(1,COURSE)*TCHQAL+TW(2,COURSE)*TCHINT+
9090    +     TW(3,COURSE)*TCHDUR
9100    75    RETURN
```

PFVECT

```
      SUBROUTINE PFVECT
COM.   REDISTRIBUTES THE STUDENTS IN THE VARIOUS ABOVE AND
COM.  BELOW THRESHOLD STATES USING THE ACHIEVEMENT INCREASE
COM.  PREDICTED BY THE INTERVENTION PROCESS
      REAL MARKOV
      INTEGER TRUANT,DROPS
      INTEGER SRVICS,FREE,RECEN
      INTEGER REL,BASE,COURSE,TYPE
      INTEGER TYPMAX,GRDMAX
      COMMON B1,B2,C1,C2,NOSTUD,TRUANT,INYEAR
      COMMON NSTLST,DSIP(3),OLDZ,SRVICS,REL(6)
      COMMON NEW(5),FREE(5),PARA(5),SPACE(5),SBUDGT(5)
      COMMON SHOURS(5),SDAYS(5),SWEEKS(5),OLDSER,DIS(6)
      COMMON SQW(2),SIW(5),SPW(5),SW(3),ZW(6),RECEN(3)
      COMMON TCHEXP(2),TCHRS(2),TEXTS(2),DESKS(2),TCHBUD(2)
      COMMON CTHRS(2),TCHDYS(2),TCHWES(2),TQW(2,2),TIW(4,2)
      COMMON TW(3,2),PP(4),S(3),SSF(3),MARKOV(4,4)
      COMMON A(2),PPLAST(4),STLAST(3),ALAST(2)
      COMMON TYPMAX,GRADE(12),DYEAR(12)
      COMMON SRVIC,BASE,OLDC(2)
      COMMON DROPS,TYPE,IG,GRDMAX,[illegible]
COM.  COMPUTE THE PASS VECTOR FROM THE SCHOOL FLOW RESULTS.
COM.  PLUS THE CHANGE IN THE PASS VECTOR DUE TO TITLE I
COM.  CYCLE FOR EACH COURSE
      DO 103,I=1,2
COM.  SET INITIAL AND JUMP LENGTHS
      INIT = 1
      NSUM = 2 **(I-1)
COM.  SET FINAL INDEX OF THE GROUP
  3   IFIN = INIT + NSUM -1
COM.  CYCLE THROUGH THE GROUP, MOVING FAILURES TO PASSES
      DO 102 J = INIT, IFIN
      L = J + NSUM
      FAILP = 1. - S(I)
      TEMP = PP(J) / FAILP * DSIP(I)
      PP(J) = PP(J) - TEMP
      PP(L) = PP(L) + TEMP
102   CONTINUE
COM.  GO TO THE NEXT GROUP OF FAILURES.
      INIT = INIT + 2 ** NSUM
COM.  HAS SUBJECT I BEEN COMPLETED?
COM.  IF NOT, GO TO 3 AND PROCESS THE NEXT BATCH OF FAILURES
      IF(INIT-4)3,103,103
COM.  CYCLE THROUGH NEXT SUBJECT
103   CONTINUE
 75   RETURN
```

DRPOUT

```
           SUBROUTINE DRPOUT
COM.       COMPUTES THE NUMBERS OF DROPOUTS AND TRUANTS
           REAL MARKOV
           INTEGER TRUANT,DROPS
           INTEGER SRVICS,FREE,RECEN
           INTEGER REL,BASE,COURSE,TYPE
           INTEGER TYPMAX,GRDMAX
           COMMON B1,B2,C1,C2,NOSTUD,TRUANT,INYEAR
           COMMON NSTLST,DSIP(3),OLDZ,SRVICS,REL(6)
           COMMON NEW(5),FREE(5),PARA(5),SPACE(5),SBUDGT(5)
           COMMON SHOURS(5),SDAYS(5),SWEEKS(5),OLDSER,DIS(6)
           COMMON SQW(2),SIW(5),SPW(5),SW(3),ZW(6),RECEN(3)
           COMMON TCHEXP(2),TCHRS(2),TEXTS(2),DESKS(2),TCHBUD(2)
           COMMON CTHRS(2),TCHDYS(2),TCHWKS(2),TQW(2,2),TIW(4,2)
           COMMON TW(3,2),PP(4),S(3),SSF(3),MARKOV(4,4)
           COMMON A(2),PPLAST(4),STLAST(3),ALAST(2)
           COMMON TYPMAX,GRADE(12),DYEAR(12)
           COMMON SERVIC,BASE,OLDC(2)
           COMMON DROPS,TYPE,IG,GRDMAX,ABAR
COM.       COMPUTE THE AVERAGE GRADE LEVEL PERFORMANCE
           ABAR=(A(1)+A(2))/2.0
COM.       COMPUTE THE AMOUNT THIS GRADE LEVEL
COM.       BEHIND THE ACTUAL GRADE.
           ALAGBA=ABAR-GRADE(IG)
COM.       READ THE DROPOUT AND TRUANCY REGRESSION COEFFICIENTS
           CALL READ(35,0,1,B1,IAA)
           B1=B1/100.
           CALL READ(36,0,1,B2,IAA)
           B2=B2/100.
           CALL READ(37,0,1,C1,IAA)
           C1=C1/100.
           CALL READ(38,0,1,C2,IAA)
           C2=C2/100.
COM.       COMPUTE THE NUMBERS OF DROPOUTS AND TRUANTS BY
COM.       REGRESSING THESE VALUES AGAINST ACHIEVEMENT LAG
           IF(IG-GRDMAX)10,10,11
      10   DYR=IG-GRADE(GRDMAX)
           GO TO 12
      11   DYR=DYEAR(IG)
      12   DROPS=(B1*ALAGBA+B2)*NSTLST*DYR
           IF (DROPS)1,2,2
       1   DROPS=0
       2   TRUANT=(C1*ALAGBA+C2)*NSTLST*DYR
           IF (TRUANT)3,4,4
       3   TRUANT=0
COM.       SUBTRACT THE DROPOUTS FROM THE NUMBER OF STUDENTS
       4   NOSTUD=NSTLST-DROPS
COM.       IF THE RESULT IS LESS THAN ZERO, SET NOSTUD
COM.       EQUAL TO ZERO AND THE NUMBER OF DROPOUTS
COM.       EQUAL TO THE PREVIOUS NUMBER OF STUDENTS.
```

DRPOUT CONTINUED

```
COM.          IF(NOSTUD)5,6,6
        5     DROPS=DROPS+NOSTUD
              NOSTUD=0
        6     ITTRG=1000*TYPE+10*IG
COM.          STORE THE NUMBERS OF DROPOUTS, TRUANTS, AND STUDENTS
COM.          IN THEIR OUTPUT FILES.
              WRITE(40,801),ITTRG,TYPE,IG,DROPS
              WRITE(41,801),ITTRG,TYPE,IG,TRUANT
              WRITE(43,801),ITTRG,TYPE,IG,NOSTUD
        801   FORMAT(I4,1X,I1,1X,I2,10I5)
              RETURN
```

CAREER

```
20COM.    COMPUTES THE NUMBERS OF THE VARIOUS STUDENT TYPES WHO
30COM.    GO INTO SELECTED CAREER CATAGORIES
100       $FILE NOSTUD, CEFIZ, A, CHOICE, INITX, DROPS
110       DIMENSION O(4), NOSTUD (4), CHOICE (4,6), SCORE (4)
120       DIMENSION PCOL(4), H(4,4), SACH(4), RELNO (4, 4)
130       DIMENSION DUMMY (33), INDEX (12)
140       COMMON TAG, A, B
150       READ(5), IGM,J1,J2,(INDEX(I),I=1,IGM)
160  9    READ(1), IT,NDEX,N
170       IF(NDEX - IGM) 19,18,19
180  18   NOSTUD (IT) = N
190  19   IF (ENDFILE 1) 9, 99
200  99   READ (2) DUMMY, H
210  39   READ(3), IT,IG,A1,A2
220       IF (IG - IGM + 1) 29, 28, 29
230  28   SACH (IT) = .6 * A1 + .4 * A2 - INDEX(IG)
240  29   IF (ENDFILE 3) 39, 939
250  939  READ(6),IT,IG,ND
260       IF (INDEX (IG) - 6) 31, 31, 32
270  32   IF (INDEX (IG) - 10) 33, 33, 34
280  34   CHOICE (IT, 3) = CHOICE (IT, 3) + ND; GO TO 91
290  31   CHOICE (IT, 1) = CHOICE (IT, 1) + ND; GO TO 91
300  33   CHOICE (IT, 2) = CHOICE (IT, 2) + ND
310  91   IF (ENDFILE 6) 939, 999
320  999  A = 1 / SQRT (6.2832);  B = .5
330       DO 73 ITYPE = 1, 4
340       SD = 2.55
350       GO TO (1, 1, 3, 3) ITYPE
360  1    SD = SD [illegible]
370  3    TAG = SACH (ITYPE) / SD
380       O(4) = W (.675, 3.5)
390       O(3) = W(0, .675)
400       O(2) = W (-.675, 0 )
410       O(1) = W (-3.5,-.675)
420       DO 73 J = 1, 4
430       PCOL(ITYPE)=PCOL(ITYPE)+O(J)*H(J,ITYPE)
440       SCORE (J) = J + ITYPE
450       RELNO (J, ITYPE) = NOSTUD (ITYPE) * O (J)
460       IF (SCORE(J) - 4) 233, 223, 74
461  74   IF (SCORE(J) - 5) 223, 223, 213
470  233  E=.06
480       F=.44
490       G=.50
500       GOTO75
510  223  E=.10
520       F=.61
530       G=.29
540       GOTO75
541  213  E=.35
[illegible] F=.47
```

CAREER CONTINUED

```
        G=.18
  75    CHOICE(ITYPE,6)=CHOICE(ITYPE,6)+RELNO(J,ITYPE)*E
        CHOICE(ITYPE,5)=CHOICE(ITYPE,5)+RELNO(J,ITYPE)*F
        CHOICE(ITYPE,4)=CHOICE(ITYPE,4)+RELNO(J,ITYPE)*G
   73   CONTINUE
        REWIND 2
        WRITE (2) DUMMY, H, PCOL
        ENDFILE 2
        WRITE (4) ((CHOICE(IX, JX), JX = 1, 6), IX = 1, 4)
        ENDFILE 4
        $CHAIN EQUAL
        END
        FUNCTION F (X)
        COMMON TAG, A, B
        F = A * EXP (-B * (X - TAG) * (X - TAG))
        RETURN
        FUNCTION W (START, STOP)
        DIMENSION P(7)
        R = START
        P(1) = P(3) = P(5) = P(7) = 1
        P(2) = P(6) = 5  ; P(4) = 6
        T = (STOP - START) / 6
        S = .3 * T
        W = 0
        DO 121 J = 1, 7
        W = W + P(J) * S * F (R)
        R = R + 1
  121   CONTINUE
        RETURN
```

EQUAL

```
COM.     COMPUTE THE INDEX OF EQUALITY OF EDUCATIONAL OPPORTUNITY
        $FILE INITX, A, DUBL07
        DIMENSION E (4, 12, 3), INDEX (12), A (4, 12, 3)
        READ (1), IGM, J1, J2, (INDEX(I), I = 1, IGM)
        IGML1 = IGM - 1
        DO 21 KTYPE = 1, 4
        DO 21 JGRADE = 1, IGML1
        READ (2), K, J, A(K, J, 1), A(K, J, 2)
  21    A (K, J, 3) = .5 * (A (K, J, 1) + A (K, J, 2) )
        DO40KRSE=1,3
        TEMP=0.
```

EQUAL CONTINUED

```
      JGRADE=0
30    JGRADE=JGRADE+1
      IF(A(4,JGRADE,KRSE)-TEMP)31,31,32
31    IF(JGRADE-IGML1)30,32,32
32    TEMP=A(4,JGRADE,KRSE)
      DO40ITYPE=1,4
      TEMPI=0.
      JGRADE=0
33    JGRADE=JGRADE+1
      IF(A(ITYPE,JGRADE,KRSE)-TEMPI)34,34,35
34    IF(JGRADE-IGML1)33,35,35
35    TEMPI=A(ITYPE,JGRADE,KRSE)
      DO40JGRADE=1,IGML1
       IF(ITYPE-4)37,36,36
36    E(ITYPE,INDEX(JGRADE),KRSE)=1.
      GOTO40
37    P=(12-INDEX(JGRADE))/11*(TEMP-TEMPI)
      E(ITYPE,INDEX(JGRADE),KRSE)=(A(ITYPE,JGRADE,KRSE)-TEMPI)
+     /(A(4,JGRADE,KRSE)-TEMPI-P)
40    CONTINUE
      WRITE(5),E
      $CHAIN COMEFF
      END
```

COMEFF

```
COM.    COMPUTES THE COMMUNITY EFFECTS
        $FILE 01, 02, 03, 04, NOSTUD, A, INITX, CEFIZ, CHOICE
        REAL INDEX
        DIMENSION DATA(7),RATA(7),YBAR(7),C(5),DPV(7)
        DIMENSION PLE(7),ELE(7),N(4),AA(5)
        DIMENSION CHOICE(6,4), DUMMY(16), COL(4)
        COMMON INDEX (12)
        READ (8), DATA, YBAR, DPV, C, RATA, DUMMY, COL
        READ (9) CHOICE
        ALPHA = .05
        READ (7) IGM, J1, J2, (INDEX (I), I = 1, IGM)
        DO LAST, I = 1, IGM
LAST:INDEX (I) = AINT (INDEX (I))
9       READ (5, A) IT, IG, NS
A:      FORMAT (5X, I1, I3, I5)
        IF (IG - 1) 431, 432, 431
432     N (IT) = NS
```

COMEFF CONTINUED

```
1120  431  IF (ENDFILE 5) 9, 999
1190  999  B12 = N (1) + N(2)
1200       B34 = N(3) + N(4)
1210       BZERO = B12 + B34
1220       DO 170 ITYPE = 1, 4
1230       PCOL = COL (ITYPE)
1240       IF (FINK (ITYPE) - YHATL) 31, 32, 33
1250  31   BY = 1 - ALPHA
1260       GO TO 36
1270  32   BY = 1
1280       GO TO 36
1290  33   BY = 1 + ALPHA
1300C       RACIAL BIAS
1310  36   BB12 = N(1) * FINK (1) + N(2) * FINK (2)
1320       BB34 = N(3) * FINK (3) + N(4) * FINK (4)
1340       GO TO (201, 201, 202, 202) ITYPE
1350  201  B = BB12 * BZERO / B12
1360       GO TO 203
1370  202  B = BB34 * BZERO / B34
1380  203  B = B / (BB12 + BB34)
1390       B = B * BY
1400C       ACHIEVEMENT LEVELS
1410       CALL R (5, AA(1))
1420       CALL R (9, AA(2))
1429       IMAX = INDEX (IGM - 1)
1430       CALL R (IMAX, AA(3))
1440       READ(3), IT, IG, A1, A2
1441  81   FORMAT (5X, I1, I3, (F6.3))
1450       AA(4) = AA(5) = .6 * A1 + .4 * A2
1600C       POTENTIAL LIFETIME EARNINGS
1610C       AND EXPECTED LIFETIME EARNINGS
1620       DO 190 I = 1, 5
1630       PLE (I) = DPV (I) * YBAR (I) * B * C (I) * AA (I)
1640       Q = DATA (I)
1650       R = RATA (I)
1660       P = PLE (I)
1670       ELE (I) = UNEMP (ITYPE, Q, R, P)
1680  190  CONTINUE
1690       PLEAC = PCOL * DPV(6) * YBAR(6) * B
1700       Q = DATA (6)
1710       R = RATA (6)
1720       ELEAC = UNEMP (ITYPE, Q, R, PLEAC)
1730       PLEAD = (1. - PCOL) * DPV(7) * YBAR(7) * B
1740       ELEAD = UNEMP (ITYPE, DATA(7), RATA(7), PLEAD)
1750       PLE(6) = PLEAC + PLEAD
1760       ELE(6) = ELEAC + ELEAD
1770       E = P = 0
1780       DO 97 M = 1, 6
1790       CH = CHOICE (M, ITYPE)
1800       E = ELE (M) * CH + E
```

COMEFF CONTINUED

```
          P = PLE (M) * CH + P
   97     CONTINUE
          PLE (7) = P / N(ITYPE)
          ELE (7) = E / N(ITYPE)
          U = (.092 * CHOICE(1, ITYPE) + .073 * CHOICE(2, ITYPE)
     +     + .048 * CHOICE (3, ITYPE) + .014 * POOL * STARA
     +     + .04 * (N(ITYPE) - CHOICE(1, ITYPE) - CHOICE(2, ITYPE) -
     +     CHOICE(3, ITYPE) - POOL * STARA)) / N (ITYPE)
          WRITE (ITYPE) (CHOICE(J,ITYPE), J = 1, 6), N(ITYPE),
     +     PLE, ELE, U
          ENDFILE ITYPE
  170     CONTINUE
          $CHAIN FLEX
   70     END
C          EARNINGS CORRECTED FOR FIRST YEAR'S UNEMPLOYMENT
          FUNCTION UNEMP (ITYPE, DATA, RATA, PLE)
          IF (ITYPE - 3) 37, 38, 38
   38     UNEMP = (1 - DATA) * PLE
          UNEMP = UNEMP + DATA * RATA * PLE
          RETURN
   37     UNEMP = (1. - 3. * DATA) *PLE
          UNEMP = UNEMP + DATA * RATA * PLE
          RETURN
C          FATHER'S INCOME
          FUNCTION FINK (ITYPE)
          GO TO (41, 42, 43, 44) ITYPE
   41     FINK = 1740; RETURN
   42     FINK = [illegible]; RETURN
   43     FINK = 1738; RETURN
   44     FINK = 8060; RETURN
          SUBROUTINE R (L, AL)
          REAL INDEX
          COMMON INDEX (12)
    9     READ(6), IT, IG, A1, A2
          IF (INDEX(IG) - L) 9, 10, 10
   10     BACKSPACE 6
          READ(6),IT,IG,A1,A2
          AL = L + (A1 + A2) / 2 - INDEX (IG) + 1
          BACKSPACE 6
          RETURN
```

FLEX

```
1000*                  NEGROES--LESS THAN $3000
1010*                  NEGROES--MORE THAN $3000
1020*                  WHITES --LESS THAN $3000
1030*                  WHITES --MORE THAN $3000
1031COM.      THE OUTPUT ROUTINE
1040          $FILE A, INITX, TRUANT, DROPS, DUBL07, 01, 02, 03, 04, FLEX
1050          DIMENSION FINDEX(12), A(12, 2, 4), NT(12, 4), ND(12, 4)
1060          DIMENSION E (4, 12, 2); INTEGER F (7, 3)
1070          READ (2) MAXGRD, J1, INYEAR, (FINDEX(J), J = 1, MAXGRD)
1080   RA:    READ (1) IT, IG, (A (IG, L, IT), L = 1, 2)
1090          IF (ENDFILE 1) RA
1100   RT:    READ (3) IT, IG, NT (IG, IT)
1110          IF (ENDFILE 3) RT
1120   RD:    READ (4) IT, IG, ND (IG, IT)
1130          IF (ENDFILE 4) RD
1140          READ (5) E
1150          MAXGRD = MAXGRD - 1
1155          IGINIT = 1
1160          DO 110 I = 1, MAXGRD
1170          IF (FINDEX (I) - INYEAR) 100, 100, 110
1180   100    IGINIT = I
1190   110    CONTINUE
1200          DO 1001 IT = 1, 4
1205          PRINT,"--------------------------------------------------------"
1206          PRINT,^^^^^,
1210          READ (10, 939);   PRINT 939
1220   939    FORMAT (24X,38H                                  )
1230          PRINT,"                          ========================="
1240          PRINT 335
1250   335    FORMAT (//10X, 5HGRADE10X,11HACHIEVEMENT10X,7HTRUANTS
1260 +         10X,8HDROPOUTS)
1270   271    PRINT,"                          ENGLISH      MATH",^
1280          PRINT 310,((FINDEX(IG), A(IG,1,IT),A(IG,2,IT),NT(IG,IT),
1290 +         ND(IG,IT)), IG = IGINIT, MAXGRD)
1300   310    FORMAT (9X,F5.1, F15.1, F10.2, I13, I15)
1310          PRINT 440
1320   440    FORMAT(//15X,36HEQUALITY OF EDUCATIONAL OPPORTUNITY //)
1330          IG=MAXGRD ;  ID= FINDEX(IG)
1340   B:     PRINT 435, ID, (E (IT, ID, L), L = 1, 2)
1350   435    FORMAT(8HGRADE = F5.1,2X,10HENGLISH = F5.2,5X,7HMATH = ,F5.2)
1360 +         7HMATH = ,F5.2)
1370          J = IT + 5
1380          READ (J) F, U
1390          PRINT,^^"                     POTENTIAL EXPECTED"
1400          PRINT,"                     LIFETIME  LIFETIME"
1410          PRINT,"            NUMBER  EARNINGS  EARNINGS"
1420          PRINT,"            ----------------------------",^^
1430          PRINT 595, (F(1,M), M = 1, 3)
1440   595    FORMAT(7HGRADE 6I11, I9, I10)
1450          PRINT," DROPOUTS"
```

FLEX CONTINUED

```
1460          PRINT 615, (F(2,M), M = 1, 3)
1470   615    FORMAT(/8HGRADE 10I10, I9, I10)
1480          PRINT,"  DROPOUTS"
1490          PRINT 645, (F(3,M), M = 1, 3)
1500   645    FORMAT(/8HGRADE 12I10, I9, I10)
1510          PRINT,"  DROPOUTS"
1520          PRINT 675, (F(4,M), M = 1, 3)
1530   675    FORMAT(/10HVOCATIONALI8, I9, I10)
1540          PRINT 695, (F(5,M), M = 1, 3)
1550   695    FORMAT(//10HCOMMERCIALI8, I9, I10)
1560          PRINT 720, (F(6,M), M = 1, 3)
1570   720    FORMAT(//8HACADEMICI10, I9, I10)
1580          PRINT,^^"===========  =======  =======   ======"
1590          PRINT 765, (F(7,M), M = 1, 3)
1600   765    FORMAT(/5HTOTALI13, I9, I10)
1630          PRINT,^^^
1640   1001   CONTINUE
1650          STOP
1660          END
```