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ABSTRACT

This mathematical model of the educational system calculates information on population groups by sex, race, age, and educational level. The model can be used to answer questions about what would happen to the flows of students and teachers through the formal educational system if these flows are changed at various stages. The report discusses the major assumptions, methodology, and mathematical properties of the model, and the scope of its data. In addition to detailed calculations for 140 population groups from 1959 to 1970, the impact of selective changes in the model's parameters on the composition of the educational population is discussed. Appendixes contain tables and charts summarizing various aspects of the model, including the Dynamod II computer program. Related documents are EA 001 018; EA 001 062; EA 001 063; EA 001 064; EA 001 066; and EA 001 067. (Author/LLR)

WORKING PAPER

STUDENT-TEACHER POPULATION GROWTH MODEL

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STUDENT-TEACHER POPULATION GROWTH MODEL

By Edward K. Zabrowski
and
Judith R. Zinter
Tetsuo Okada

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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OFFICE OF EDUCATION: Harold Howe II, Commissioner

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F. C. Nassetta, Acting Assistant Commissioner

David S. Stoller, Director, Division of Data Analysis and Dissemination

FOREWORD

The Student-Teacher Population Growth Model (Dynamod II) is a mathematical model of the formal American educational system. It calculates information on 140 population groups cross-classified by sex, race, age and educational level. It can be used to answer many (but certainly not all) questions about what would happen to the flows of students and teachers through the formal educational system if these flows at various stages are changed.

This report touches on several topics. The Introduction discusses the major assumptions used in developing the model, the scope of the data, and the methodology of the model, including some of the model's mathematical properties.

The section "Results and Analysis" first presents the detailed calculations from the model for the 140 population groups, spanning the academic years from 1959-60 to 1969-70. The discussion "Special Analyses" contains some illustrations of what can be done with a model of this type. That is, the impact on the calculations of the composition of the educational population caused by making selective changes to the model's parameters are traced through time. Such changes reflect what could be the effects either of Government policy or of autonomous shifts in tastes, preferences or habits in the population.

In the Appendixes will be found a large number of tables and charts summarizing various aspects of the detailed information presented in the Results section. In addition, the Dynamod II computer program is presented and briefly explained.

The development of a mathematical model quite often rapidly distinguishes those portions of an existing data base that need to be augmented. Even with a relatively abbreviated model such as Dynamod II the gap in the amount of available data compared to that required for the model was considerable. As a result of the model's development we now have a much clearer picture of what additional statistics need to be included in our growing general information systems, and plans for future surveys in educational statistics will reflect the knowledge gained thereby.

David S. Stoller
Director
Division of Data Analysis
and Dissemination

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HIGHLIGHTS OF THE REPORT

DYNAMOD II is a computerized Markov-type model which calculates the responses to changes in its parameters for 140 population groups over selected intervals of time. These population groups are composed of four sex-race groups cross-classified as to age (six categories) and educational status (three levels each of students and teachers as well as elementary and secondary school dropouts). Included also are "other" categories which contain the segments of the population which are classified as not being in the educational sectors.

The model uses over 832 transition probabilities to estimate the population flows in each year. Birth projections are introduced independently to the appropriate sex-race categories after each iteration of the model.

The model is programmed for the RCA 3301 and GE time-sharing computer systems. On the GE system, a data file arrangement permits on-line access to any of the inputs or probabilities. In addition, user options regarding the desired amount of detailed output are available.

The DYNAMOD II calculations for the period 1959-60 to 1969-70 by individual groups are presented without detailed discussion. Dropout calculations indicate that, under present trends, total elementary and secondary school dropouts will rise to 1.7 million in 1968-69 from 1.2 million in 1959-60. In the secondary school sector, dropouts will increase to 1.4 million in 1968-69 from 958 thousand in 1959-60. Of the 1.4 million figure, 1.2 million or 84 percent will be white.

A series of tests was conducted to estimate the impact of a hypothetical change introduced in 1959-60 designed to keep one more student or teacher respectively, per hundred in the educational system. The results, relative to the original calculations, are summarized as follows:

1959-60	1969-70
A one-percent increase in the retention rates of:	Would have increased their totals by this percentage:
Elementary school students	1.3
Secondary school students	2.1
College students	3.0
Elementary school teachers	5.8
Secondary school teachers	4.8
College teachers	5.9

The secondary impacts, or "spillover" of the retention rate changes also were traced. That is, the impact on the secondary school student sector, college student sector, etc., brought on by increasing the elementary school student retention rate was examined. This was done for all three student levels. The usual pattern was a dampening effect. For example, in the case of increased retention of elementary school students, (1.3 percent by 1969-70), the secondary school population would eventually increase 1.2 percent and the college sector by less than that, probably .8 percent.[1]

Examinations of the effects of student and teacher retention rate changes on the respective student-teacher ratios showed that for all levels of schooling the ratio was relatively more responsive to changes in the retention rates of teachers than of students. It is shown that disparities such as these can be employed to advantage by policymakers in what is termed "policy sequencing." A description of policy sequencing relating to objectives of decreasing dropout rates subject to constraints on the permitted level of the student-teacher ratio and the allowable action time is presented in the text.

The construction of the model involved the specification and estimation of the population groups' crossflows, which provides interesting information regarding the structure of the educational system. For example, it is estimated that of the nearly 1.2 million elementary school teachers expected to be teaching in 1968-69, 91 thousand will leave teaching. New entries from college in 1969-70, 62 thousand, will not be sufficient to replace the losses, let alone provide for a growth increment. Replacement and provision for growth mainly will have to come from secondary school transfers (36 thousand) and from outside the system (36 thousand).

The relative importance of entries from outside the system to the three teaching levels was tested by an extreme case. Within each teaching sector the retention rates were set to the survival rates (1.0000 minus the death rate), while permitting as sources of entry only the present flows of college students. The results indicated that the elementary and secondary school sectors could meet their replacement and growth requirements from within their sectors, if the sectors would in fact respond to retention-increasing policies. The college teaching sector, highly dependent on entries from outside

[1] The effect had not fully worked itself out by the end of the calculational interval. Increasing the elementary school retention rate by one percent would virtually eliminate elementary school dropouts. Knowledgable educators have pointed out that some proportion of dropouts probably are uneducable. How many of these dropouts are "uneducable" is in part a function of how much of our resources we would be willing to allocate to their reclamation. The balance, then, would be the hard core dropout.

the system, could not satisfy the basic requirements from within the sector. Unless marked alterations in the flows of college students into college teaching occur, this dependence on external entries should persist.

In the appendixes will be found most of the statistical material and summary data for the report. Appendix A in particular contains a presentation of the summary calculations of the model as well as the projections of the Office of Education and the Bureau of the Census, against which the calculations were calibrated.

INTRODUCTION

Background

In September, 1966, an unpublished paper entitled "DYNAMOD I: A Research Demographic Model," was completed. That paper demonstrated the feasibility of applying Markov chain analysis to the growth and composition of the educational population of students and teachers.

The model presented in this publication, DYNAMOD II, was developed on the basis of the lessons learned from DYNAMOD I. It is a more finely structured and consequently more accurate model than was DYNAMOD I. As such, DYNAMOD II should prove to be of use to all educational officials, planners and analysts who are interested in examining the impact of policy alternatives on the educational population at the national level.

DYNAMOD II's calculations approximate the population projections of other Federal agencies well enough to provide the educational community with "order of magnitude" estimates of the effects of variations in certain key items, such as student- and teacher-retention rates or birth rates, until a new model, Student-Teacher Analysis of Growth, (STAG) becomes operational.

Basic Assumptions

The basic assumptions used in DYNAMOD II are as follows:

1. A Markov-type process is a suitable means for representing the flows of people among categories. The technical definition of a Markov process can be found elsewhere.[1] As the concept pertains to DYNAMOD II, the population is divided into various cross-classifications based on sex, race, age, and the educational categories that the groups are in. Then estimates, called "transition probabilities" are made of the chances that a member of a group in one year will stay in that group or move to another specific group the next year. After one cycling of the model, the newly formed groups are multiplied by the appropriate probabilities to determine the structure of the population in the following year. This process can be continued indefinitely;

1/ William Feller, An Introduction to Probability Theory and Its Applications, Volume I, Second edition, John Wiley and Sons, Inc. (New York: 1957), p. 369. A simpler but less extensive treatment of Markov chains can be found in John G. Kemeny, J. Laurie Snell and Gerald L. Thompson, Introduction to Finite Mathematics, Second Edition, Prentice-Hall, Inc. (Englewood Cliffs: 1966), pp. 194-198 and pp. 271-287.

DYNAMOD II is not a true Markov process, at least in the con-

2. The transition probabilities are fixed during the calculation interval; and

3. Death rates are fixed during the calculation interval.

The above description can be considered to be a sketch of the way DYNAMOD II operates. Of course, a large computer model which grapples with the complexities of reality must be, of itself, complex. Nevertheless, DYNAMOD II provides a capability for analysis not easily filled by other means. For example, estimates of the numbers of people in educational policy target populations (such as young nonwhite boys in secondary school) are available in DYNAMOD II, but not elsewhere, because that type of data is not collected in such detail in most surveys. The 1960 Census of Population collected such information, however, and in conjunction with estimates of transition probabilities to describe the flows and crossflows of the population, provided the means for making projections of the numbers in those groups for a predetermined number of years.

Furthermore, by hypothesizing the effects that policy changes would have on the transition probabilities, an assumed impact on the population can be quantified.

Scope of Data

DYNAMOD II is in every sense a large population model. It features a population divided into:

Footnote 1 continued

ventional sense. One might best consider DYNAMOD II as a Markov process superimposed over a growth function representing net births. In a conventional Markov process, one has the alternatives of either cycling the basic population (row) vector, P, n times through the transition matrix T, or calculating $P(T^n)$ to determine the distribution of the various population groups in year n, where (T^n) is the n th power of the matrix T. The occurrence of net births in the model prevents the use of the second alternative, even if it were desired--but the population groups in DYNAMOD II must be cycled each time, to get the needed data on an annual basis.

- elementary school students
- elementary school dropouts
- secondary school students
- secondary school dropouts
- college students
- elementary school teachers
- secondary school teachers
- college teachers
- other (i.e., persons who are neither students nor active teachers)

The population is further divided by sex and race (i.e., white and nonwhite), and into age levels 0-4, 5-14, 15-19, 20-24, 25-44 and 44 years or older. In all, there are 140 separate population groups (including dropouts and deaths) in DYNAMOD II, which required the estimation of over 830 separate probabilities to describe the groups' crossflows among categories. A listing of the population groups is given on pages 10 and 11.

Student and teacher data are centered on the academic year beginning in September. Data on the remainder of the population are centered on April of the following year.

Data for students and teachers include both public and nonpublic schools, but not schools such as residential schools for exceptional children, subcollegiate departments of institutions of higher education, Federal schools for Indians, or schools in Federal installations. Since the data from the Bureau of the Census' 1/1,000 sample were forced into agreement (see "Methodology" below) with those published by the Office of Education,2/ Office of Education definitions are applicable.

Elementary school students are defined in this paper to be those children in kindergarten through grade 8, and secondary school students are those in grades 9 through 12. College student figures apply to opening fall degree-credit enrolled students, full time and part time. The full-time-equivalent concept was not used for students.

The three teacher categories (elementary, secondary and college) are also alined with Office of Education definitions, except that, as with students, full-time equivalents were not calculated.

It should be noted that gradewise, the elementary- and secondary-teacher categories are not directly comparable to the respective student

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2/ U.S. Department of Health, Education, and Welfare, Office of Education, Projections of Educational Statistics to 1974-75, OE-10030-65 (Washington, D. C.: Supt. of Documents, U.S. Government Printing Office), 1965.

categories. That is, a proportion of teachers in grades 7 and 8 are actually classified as secondary for Office of Education definitional purposes. The effects of these differences on the student-teacher ratios are discussed in Appendix D.

Methodology

The following paragraphs summarize the methodology employed in the development of DYNAMOD II. The methodology of DYNAMOD II involved two distinct problems--the selection of the structure of the mathematical model, and the methodology of estimating data inputs. These problems are highlighted below.

Model structure.- The mathematical form of DYNAMOD II is:

$$N_j = \sum_{i}^{i_{max}} N_i P_{ij} + B_j, \text{ where}$$

N = a grouping of people;

i = a sex-race-age-educational level group identifier for year t;

i_{max} = the highest-level i-type identifier;

j = a sex-race-age-educational level group identifier for year t+1;

P_{ij} = the probability that an individual in group i will change to group j (a transition probability); and

B_j = the number of births in year t+1.

In the model, death rates are included as specific P_{ij}'s, while births are brought in as an exogenous variable.

To illustrate more clearly how a model of this type operates, assume hypothetically that the population is composed of two groups, 1 and 2, which represent "young" and "old" respectively. Assume that:

B_j = 10 per year;

N_1 = 50 in year t;

N_2 = 100 in year t; and

the P_{ij} matrix is

i \ j	1	2
1	.7	.3
2	0	1.0

The transition probabilities indicate (row 1) that 70 percent of those who are young will stay young, and 30 percent of those who are young will become old. In row 2, none of the old can become young.

In year t+1, there will be

50 (.7) + 100 (0.0) + 10 = N_1 = 45 young people, and

50 (.3) + 100 (1.0) = N_2 = 115 old people (since there is no death rate.)

In like manner, the calculations for year t + 2 will produce

45 (.7) + 115 (0.0) + 10 = N_1 = 41.5 young people, and

45 (.3) + 115 (1.0) = N_2 = 128.5 old people.

With such a large model as DYNAMOD II, the calculating procedures are slightly more involved than those indicated in with the example above, depending on the type of computer being used.

DYNAMOD II recently has been run on two computing machines--the RCA 3301 and the GE-235 time-sharing system. One of the convenient features of the time-sharing system is that data files can be created and left in disk storage for use "on stream" or at another time. This feature is exploited for the DYNAMOD model by creating four data files: white males, white females, nonwhite males and nonwhite females. Within each file the number of people in each subgroup and their respective transition probabilities are stored according to identifiable line number addresses.

These data files contain the number of people in the various categories, birth vector elements, and the transition probabilities. The files are then united with the computer program and the calculational process proceeds in the manner shown in figure 1.3/

To temporarily change the parameters for analytical output runs, a few simple steps are followed that instruct the time-sharing system to duplicate the files. Next, the line number address is retyped, the new line of data is entered, and so on, until all changes have been introduced. If the number of changes is small, they can be made "on stream." Then the program is rerun using the new data files. After that, the new files can be saved or deleted. The old files containing the base data are undisturbed in the process.

Presently, there are 3 variations of the time-sharing computer program for DYNAMOD II. One program prints out data for each of the 140 population groups as well as selected subtotals for each year in the interval of calculation. Another program permits the user to select predetermined output combinations by responding to a series of preprogrammed questions. The third program merely prints out selected subtotals for the four sex-race groups.

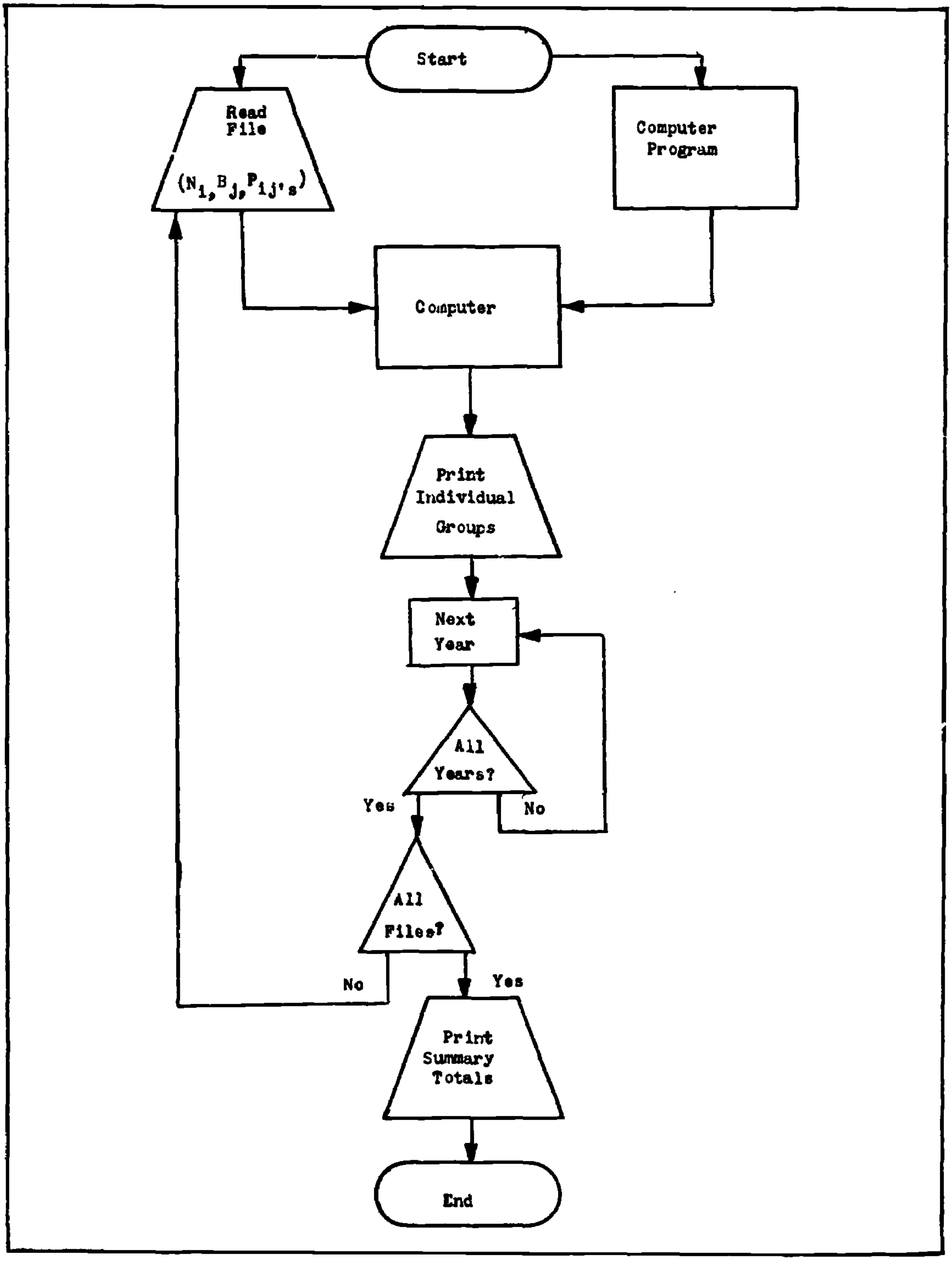
Data inputs. The Bureau of the Census 1/1,000 sample of the 1960 Census unit records served as the primary data source for the DYNAMOD II inputs. Several adjustment procedures were necessary, however, to transform the Census data into a form acceptable as final input, as described in the following paragraphs.

First, the DYNAMOD II design requires that the individual population groups be mutually exclusive. That is, an individual must be classified as either a student or a teacher-- he cannot be both. The Bureau of the Census' tape did not meet this requirement, so it was necessary to allocate individuals manually to one specific group. This was done using income as a criterion. For example, an individual classified as both student and teacher would be allocated to the student group if his income was less than $3,000. If his income was $3,000 or more he would be classified as a teacher. Although the use of income as a criterion was known to be a less than perfect discriminant, its use did minimize significantly the assignment of teachers to student categories. This can be readily shown by a table of faculty salaries.4/

3/ A detailed description of the DYNAMOD II computer program is presented in William K. Winters, DYNAMOD II in a Time-Sharing Environment, U.S. Office of Education, National Center for Educational Statistics, Technical Note No. 45, October 23, 1967.

4/ U.S. Department of Health, Education, and Welfare, Office of Education, Digest of Educational Statistics, 1962, OE-10024, Bulletin 1963, No. 10, table 68.

Figure 1.-Flow chart of DYNAMOD II computing procedures



Secondly, because of sampling error, the 1/1,000 sample data yielded estimates of the various age groups somewhat lower than those estimates published by the Bureau of the Census in the Current Population Survey, Report P-25, No. 359. Since the initial error introduced by the underestimate would have been compounded through the calculation years by DYNAMOD II, the following adjustment was necessary:

For each sex-race group

$$G'_{ij} = \frac{N'_i}{N_i} G_{ij}$$

where i indicates the age group;

j indicates the student-teacher group;

G' = adjusted individual population group, ij;

G = initial individual population group, ij;

N_i = number of individuals from Current Population Survey Report in age group i; and

N = number of individuals from 1/1,000 sample in age group i.

Finally, the Bureau of the Census and the Office of Education differ in their estimates of student and teacher populations. This occurs because of differences in definition, in survey technique, and in the date of survey. Since Office of Education data were to be used for comparison purposes, the Bureau of the Census data were adjusted once more to bring it into agreement with Office of Education data. This was done in the following manner:

$$G''_{ij} = \frac{N''_i}{N'_j} G'_{ij}$$

where i, j, and G' are as defined above;

G'' = final input for population group ij

N'_j = number of individuals in student-teacher group j (from Census data)

N''_j = number of individuals in student-teacher group j (from Office of Education data)

When the number of students or teachers in these individual population groups (G''_{ij}) differed from G'_{ij} as a result of the adjustments just described, the net change was absorbed by the "Other" category. Thus, the input by age was kept in agreement with those estimates from the Current Population Survey, Report No. 359. The final inputs are shown in table 1.

Birth projections in absolute numbers by sex and race were used in the model, as opposed to the rate concept used for deaths. (See Death rates below.) Two sets of birth data were utilized in DYNAMOD II. The first was Series B as published by the Bureau of the Census.5/ These data provided information on the numbers of births by race. Estimates of the within-race male-female distributions, not published in that document, were made within the Division of Operations Analysis.6/

The second set of birth projections used in DYNAMOD II, Series D, was independently estimated (appendix table B-1).7/ It was felt that there was a distinct need for an independent set of estimates, because there was a marked discrepancy between the published Series B data and the births actually being realized in the population. The results for both sets of birth projections are presented later in this report. To maintain an approximate reference comparison, however, the Series B data have been used in the DYNAMOD II base line calculations, as well as in the projections where the student- or teacher-retention rates have been varied.

Wherever applicable, death rates described in Technical note number 11 were modified for DYNAMOD II to make use of differential

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5/ U.S. Bureau of the Census, Current Population Reports, Population Estimates, Series P-25, No. 345, "Projections of the White and Nonwhite Population of the United States, by Age and Sex, to 1985," July 29, 1966. These birth projections are slightly lower than those used in the Series E projections which are based mainly on Current Population Reports, Series P-25, No. 329.

6/ The proportions used to allocate male and females within the races were the same as those shown in paper by T. Okada, "Birth and Death Projections Used in Present Student-Teacher Population Growth Model," Technical Note Number 11, December 14, 1966.

7/ Ibid.

Table 1.-Population groups used as inputs to DYNAMOD II
(Thousands)

Age groups (years)	Male White	Male Nonwhite	Female White	Female Nonwhite
Elementary school students:				
0-4	156	34	147	46
5-14	13,423	1,993	12,888	1,966
15-19	334	116	196	68
20-24	28	17	14	11
25-44	29	8	26	11
Secondary school students:				
5-14	669	70	720	107
15-19	3,290	381	3,121	372
20-24	140	30	88	35
25-44	124	11	89	24
College students:				
15-19	612	22	582	38
20-24	919	47	417	31
25-44	511	33	148	17
Elementary school teachers:				
20-24	13	5	92	7
25-44	76	10	279	36
44+	28	5	381	20
Secondary school teachers:				
20-24	22	1	34	2
25-44	187	13	91	11
44+	73	2	134	10
College teachers:				
25-44	114	6	29	4
44+	89	6	33	2

Table 1 cont'd.

Table 1 (Cont'd.)

Age groups (years)	Male		Female	
	White	Nonwhite	White	Nonwhite
Other:				
0-4	8,707	1,455	8,376	1,444
5-14	1,683	329	1,569	318
15-19	1,766	294	1,930	345
20-24	3,791	547	4,205	620
25-44	19,701	2,374	20,512	2,660
44+	22,779	2,258	24,665	2,380

mortality rates by occupation.8/ For male teachers, separate mortality rates were obtained for both white and nonwhite from mortality rates based on occupation and age grouping. Their female counterparts were derived by assuming that the female teacher population exhibited the same male-to-female mortality ratios as in the general population.9/

Mortality rates for college students in the 15-19 age interval were assumed to be the same as for teachers in the 20-24 year interval, which are less than those for the general population of 15-19 year olds. College students in the remaining age intervals were assumed to have the same death rates as teachers. For elementary and secondary school students, death rates used in the model were those for the general population. (See appendix table B-6 for the death rates actually used in DYNAMOD II.)

Estimates of transition probabilities.- The estimating procedures can be summarized briefly as follows:

1. First approximations to the probabilities for males and females were developed from whatever data sources could be utilized, as well as from theoretical and empirical knowledge of the problem.

2. The male and female transition probability matrices were then adjusted by iterating the population several times, comparing the results to reference data, adjusting the probabilities, reiterating, etc., until the fit to the reference data was deemed acceptable.

3. Next, the male and female transition probability estimates were "factored" into their four respective age-race transition matrices. For example, the male elementary school student retention probability was broken into the retention rates for those white and nonwhite students who were 0-4, 5-14, 15-19, 20-24, and 24-44 years of age, respectively. The original estimates of the age-education transition

8/ U.S. Department of Health, Education, and Welfare, Public Health Service, National Vital Statistics Division, "Mortality by Occupation and Industry Among Men 20 to 64 Years of Age: United States, 1950," Vital Statistics-Special Reports, Vol. 53, No. 2, September, 1962. (Washington, D.C.: Supt. of Documents, U.S. Government Printing Office), table 2.

9/ U.S. Department of Health, Education, and Welfare, Public Health Service, National Center for Health Statistics, Vital Statistics of the United States, Vol. II - "Mortality, Part A." (Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1966), table 1-25.

probabilities were completely mechanical. Thus, selected manual adjustments to render these estimates logically acceptable were required before computerized iterations could take place. As an example, consider the fact that the probability of a 0-4 year old child becoming 5-14 years old next year is roughly .2. In initial calculations, .2 would be multiplied by the probability of remaining an elementary school student. However, the probabilities of age and educational status are not independent, at least at the extreme ends of the age distributions. In fact, the probability of a child who is now a 0-4 year old elementary school student becoming a 5-14 year old elementary school student next year is actually quite high, because nearly all 0-4 year old elementary school students are 4 years old. This meant that the original estimate would have to be adjusted to account for the lack of statistical independence. The remaining probabilities in the matrices were screened in this manner and adjusted when necessary.

4. Finally, the four large matrices were used to iterate the population, primarily by computer calculations. After each iteration, the results were checked with reference data. Because of the large number of coefficients involved, the initial corrections were made to the white males matrix, with manual iterations made to that group to determine whether or not the approximate degree of correction desired was being achieved. The next step was to change the coefficients of the other three matrices proportionately and recompute the 10-year calculations. This process was continued until the calculations all fell within the acceptable tolerance limits.

RESULTS AND ANALYSES

Presented below are the results of the computer calculations for DYNAMOD II and some special analyses indicative of the types of information the model can provide.

Student-Teacher Population by Population Grouping

One of the advantages of DYNAMOD II is that it is directed in detail toward those population groups which are, by and large, the targets of policymakers. As an example, one of the specific groups in DYNAMOD II is: "male nonwhites 15-19 years of age who are in secondary schools." This group, among many others, has its own educational flow characteristics and, therefore, is suitable as a policy target.

One of the disadvantages of working with relatively minute groups is the scarcity of reference data against which the calculations can be calibrated. As a result, the relative error of the calculation for individual groups may be substantially higher than is the case for the more aggregated groupings, such as "nonwhite males." Since a model really is never complete, changes will be made to the parameters as additional information becomes available, and over a period of time, the accuracy of the detail should improve.

The enormity of space required to show the hypothesized effects of policy changes on individual groups precludes that type of presentation in this publication. However, the individual group calculations for a 10-year period are presented below for the reader's inspection.1/

Age and educational category abbreviations. Table 2 contains a listing of the age and educational categories used in DYNAMOD II and the abbreviations of those categories used in tables 3, 4, 5, and 6. When the age and educational categories are combined, there are 35 acceptable combinations used for each of the four sex-race groups.2/

1/ The 1959-60 academic year is not counted as a calculation since it is merely a relisting of the inputs. Thus, 11 years of data are presented, but only 10 years are considered as calculations in the model.

2/ Impossible combinations, such as "0-4 year old college students" were screened out. Other possible combinations did not appear on the sample data tape and were not included because of the very small numbers of people involved.

Table 2.-Age and educational categories, with abbreviations, used in DYNAMOD II

Age/educational category	Abbreviation 1/
0 - 4 years of age	0 - 4
5 - 14 " " "	5 - 14
15 - 19 " " "	15 - 19
20 - 24 " " "	20 - 24
25 - 44 " " "	25 - 44
44 or more " " "	44+
Elementary school student	ES
Elementary school dropout	ESDO
Secondary school student	SS
Secondary school dropout	SSDO
College student	CS
Elementary school teacher	ET
Secondary school teacher	ST
College teacher	CT
Other	O
Dead	D

1/ Abbreviations used in tables 3 through 6.

DYNAMOD II calculations of individual groups, 1959-60 to 1969-70.- Tables 3 through 6 contain the DYNAMOD II calculations by age and educational category for each of the four sex-race groups. The meanings of the abbreviations of the age/educational categories were given in table 2. Since the data are so extensive, the results are presented with few comments, as follows.

First, the presently declining birth rates are reflected in the "0-4 ES" and "0-4 O" groupings through 1967-68, when by using Bureau of the Census Series B birth projections, the total 0-4 years old population begins to rise. The reason that the 0-4 population does not rise immediately when the birth projections begin to rise (see appendix A, figure A-11) is because the increment of births does not offset the numbers transferred out of the 0-4 year old interval into the 5-14 year old group.

Second, dropouts shown for a given year are actually those that occurred in the previous year. For example, in table 3, the figure of 12 thousand for 5-14 year old elementary school dropouts shown for 1960-61 really indicates the estimate of the number of dropouts that occurred in the 1959-60 academic year that had survived to the fall of 1960.

Third, data on deaths are cumulative. Again referring to table 3, it is estimated that from April of 1960 to April of 1961, 851 thousand white males died. From April of 1961 to April of 1962, 861 thousand white males died (1,712 thousand minus 851 thousand).

Fourth, the values of selected "Other" categories in tables 3-6 (e.g., 15-19 O) may appear to decline rapidly from 1959-60 to 1960-61. This is due mainly to the effects of the dropout categories, which first receive numbers in 1960-61 and take away numbers that would otherwise be in the "other" category.

Dropouts, 1959-60 to 1968-69. A dropout in DYNAMOD II is defined to be "... an elementary or secondary school pupil who has been in membership during the regular school term and who withdraws from membership before graduating from secondary school (grade 12) or before completing an equivalent program of studies."3/

3/ U.S. Department of Health, Education, and Welfare, Office of Education, Combined Glossary of Standardized Items and Terms Presented in the Handbooks in the State Educational Records and Reports Series, March 1966.

Table 3.-DYNAMOD II calculations of white male population groups, by age and educational category, 1959-60 to 1969-70[1/]
(Thousands)

Age/ educational category	1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
0 - 4 ES	156.	156.	156.	154.	153.	151.	148.	145.	143.	142.	143.
0 - 4 O	8707.	8677.	8610.	8522.	8427.	8267.	8064.	7955.	7936.	7987.	8095.
5 - 14 ES	13423.	13818.	14158.	14474.	14753.	14988.	15177.	15314.	15406.	15474.	15536.
5 - 14 SS	669.	871.	917.	942.	964.	983.	999.	1012.	1021.	1028.	1033.
5 - 14 ESDO	.	012.	012.	13.	13.	13.	13.	14.	14.	14.	14.
5 - 14 SSDO	.	7.	9.	9.	9.	10.	10.	10.	10.	10.	10.
5 - 14 O	1683.	1678.	1716.	1732.	1735.	1733.	1722.	1703.	1690.	1687.	1694.
15 - 19 ES	334.	337.	344.	352.	360.	367.	375.	381.	387.	391.	395.
15 - 19 SS	3290.	3514.	3837.	4125.	4372.	4586.	4770.	4928.	5062.	5174.	5266.
15 - 19 CS	612.	732.	821.	905.	985.	1059.	1125.	1185.	1238.	1284.	1323.
15 - 19 ESDO	.	74.	75.	77.	79.	80.	82.	83.	85.	86.	86.
15 - 19 SSDO	.	296.	319.	347.	373.	395.	413.	430.	444.	455.	465.
15 - 19 O	1766.	1082.	943.	888.	878.	892.	916.	943.	969.	993.	1015.
20 - 24 ES	28.	30.	32.	33.	35.	36.	37.	38.	39.	40.	40.
20 - 24 SS	140.	137.	142.	149.	158.	167.	176.	184.	191.	198.	204.
20 - 24 CS	919.	917.	964.	1034.	1114.	1200.	1285.	1367.	1445.	1516.	1582.
20 - 24 ET	13.	14.	15.	17.	19.	21.	22.	24.	27.	29.	31.
20 - 24 ST	22.	34.	43.	51.	58.	64.	71.	77.	84.	90.	95.
20 - 24 ESDO	.	.	.	.	.	.	.	.	.	1.	1.
20 - 24 SSDO	.	82.	87.	95.	102.	108.	113.	118.	122.	125.	128.
20 - 24 O	3791.	4077.	4231.	4324.	4408.	4506.	4623.	4758.	4908.	5067.	5230.
25 - 44 ES	29.	29.	30.	30.	31.	32.	33.	34.	35.	36.	37.
25 - 44 SS	124.	126.	128.	130.	133.	137.	142.	147.	153.	159.	165.
25 - 44 CS	511.	564.	602.	638.	675.	714.	757.	802.	848.	895.	941.
25 - 44 ET	76.	80.	85.	89.	93.	98.	103.	108.	114.	120.	127.
25 - 44 ST	187.	187.	191.	196.	203.	211.	221.	231.	243.	255.	268.
25 - 44 CT	114.	0125.	135.	145.	154.	163.	171.	179.	188.	196.	204.
25 - 44 ESDO	.	2.	2.	2.	2.	2.	2.	2.	02.	02.	02.
25 - 44 SSDO	.	6.	7.	7.	7.	7.	7.	8.	8.	8.	8.
25 - 44 O	19701.	19368.	19133.	18948.	18800.	18688.	18612.	18574.	18575.	18615.	18693.
44 + ET	28.	31.	34.	37.	40.	43.	46.	49.	52.	55.	58.
44 + ST	73.	77.	81.	84.	88.	91.	95.	99.	103.	107.	111.
44 + CT	89.	95.	101.	108.	114.	120.	126.	132.	138.	144.	150.
44 + O	22779.	23054.	23305.	23538.	23755.	23960.	24154.	24340.	24519.	24695.	24868.
Cumul. D	.	851.	1712.	2581.	3457.	4340.	5230.	6125.	7027.	7935.	8851.

1/ Educational groups centered on academic year; "other" centered on April.

Table 4.-DYNAMOD II calculations of white female population groups, by age and educational category, 1959-60 to 1969-70 1/
(Thousands)

Age/ educational category	1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
0 - 4 ES	147.	148.	147.	146.	144.	142.	139.	136.	134.	134.	135.
0 - 4 O	8376.	8335.	8260.	8167.	8069.	7912.	7715.	7609.	7589.	7636.	7736.
5 - 14 ES	12888.	13287.	13581.	13854.	14090.	14286.	14439.	14543.	14608.	14653.	14694.
5 - 14 SS	720.	838.	873.	894.	913.	928.	942.	952.	959.	964.	967.
5 - 14 ESDO	.	23.	24.	24.	025.	25.	26.	26.	26.	26.	26.
5 - 14 SSDO	.	9.	10.	10.	11.	11.	11.	11.	11.	11.	11.
5 - 14 O	1569.	1496.	1529.	1539.	1539.	1535.	1523.	1504.	1492.	1490.	1496.
15 - 19 ES	196.	237.	270.	295.	315.	331.	344.	354.	362.	368.	372.
15 - 19 SS	3121.	3167.	3298.	3426.	3542.	3645.	3737.	3816.	3884.	3938.	3982.
15 - 19 CS	582.	619.	642.	666.	691.	716.	739.	761.	781.	798.	814.
15 - 19 ESDO	.	47.	54.	59.	63.	66.	69.	71.	73.	74.	75.
15 - 19 SSDO	.	350.	358.	373.	387.	400.	411.	421.	430.	437.	443.
15 - 19 O	1930.	1554.	1565.	1595.	1635.	1679.	1722.	1763.	1800.	1832.	1861.
20 - 24 ES	14.	16.	19.	22.	025.	28.	30.	32.	34.	36.	37.
20 - 24 SS	88.	91.	98.	104.	110.	116.	121.	125.	129.	132.	135.
20 - 24 CS	417.	525.	605.	664.	711.	751.	787.	819.	848.	874.	898.
20 - 24 ET	92.	91.	93.	98.	103.	109.	115.	122.	128.	133.	139.
20 - 24 ST	34.	36.	39.	43.	48.	52.	55.	59.	62.	65.	67.
20 - 24 ESDO	.	4.	5.	5.	6.	6.	6.	7.	7.	7.	7.
20 - 24 SSDO	.	85.	86.	90.	93.	97.	99.	102.	104.	106.	108.
20 - 24 O	4205.	4289.	4461.	4628.	4799.	4975.	5153.	5331.	5506.	5676.	5837.
25 - 44 ES	26.	24.	23.	23.	23.	24.	025.	26.	27.	29.	31.
25 - 44 SS	89.	87.	86.	87.	88.	90.	93.	96.	99.	102.	106.
25 - 44 CS	148.	184.	227.	270.	310.	346.	378.	407.	434.	457.	479.
25 - 44 ET	279.	280.	282.	287.	293.	302.	312.	324.	336.	350.	364.
25 - 44 ST	91.	93.	96.	101.	106.	113.	120.	127.	135.	143.	150.
25 - 44 CT	29.	34.	38.	42.	46.	50.	54.	57.	60.	64.	67.
25 - 44 ESDO	.	1.	1.	1.	1.	1.	1.	1.	1.	01.	01.
25 - 44 SSDO	.	5.	5.	5.	5.	5.	5.	5.	5.	5.	6.
25 - 44 O	20512.	20246.	20040.	19888.	19787.	19733.	19724.	19758.	19832.	19941.	20083.
44 + ET	381.	381.	381.	382.	383.	385.	387.	391.	394.	399.	404.
44 + ST	134.	133.	133.	133.	133.	134.	136.	137.	140.	142.	145.
44 + CT	33.	35.	37.	40.	42.	45.	48.	51.	53.	56.	59.
44 + O	24665.	25174.	25658.	26121.	26567.	26997.	27416.	27825.	28227.	28625.	29020.
Cumul. D	.	627.	1264.	1913.	2571.	3239.	3916.	4603.	5298.	6002.	6716.

1/ Educational groups centered on academic year; "other" centered on April.

Table 5.-DYNAMOD II calculations of nonwhite male population groups, by age and educational category, 1959-60 to 1969-70[1/]

(Thousands)

Age/ educational category	1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
0 - 4 ES	34.	38.	39.	39.	39.	40.	40.	39.	39.	39.	40.
0 - 4 O	1455.	1482.	1502.	1515.	1529.	1525.	1504.	1499.	1509.	1530.	1562.
5 - 14 ES	1993.	2160.	2238.	2310.	2380.	2447.	2509.	2562.	2608.	2649.	2689.
5 - 14 SS	70.	126.	142.	148.	153.	158.	163.	167.	170.	174.	176.
5 - 14 ESDO	.	10.	10.	11.	11.	11.	12.	012.	012.	13.	13.
5 - 14 SSDO	.	3.	6.	6.	7.	7.	7.	7.	8.	8.	8.
5 - 14 O	329.	236.	238.	245.	0250.	254.	256.	256.	256.	259.	262.
15 - 19 ES	116.	96.	84.	77.	72.	69.	67.	67.	67.	67.	68.
15 - 19 SS	381.	428.	506.	577.	638.	689.	734.	773.	807.	838.	864.
15 - 19 CS	22.	36.	47.	58.	69.	79.	87.	95.	102.	109.	114.
15 - 19 ESDO	.	20.	17.	15.	14.	14.	14.	13.	13.	14.	14.
15 - 19 SSDO	.	37.	44.	51.	58.	63.	68.	72.	76.	79.	82.
15 - 19 O	294.	200.	182.	178.	184.	193.	205.	217.	228.	239.	0250.
20 - 24 ES	17.	16.	14.	13.	11.	10.	9.	9.	8.	8.	8.
20 - 24 SS	30.	27.	25.	025.	25.	26.	28.	29.	30.	31.	32.
20 - 24 CS	47.	50.	58.	68.	80.	93.	106.	118.	129.	140.	149.
20 - 24 ET	5.	4.	4.	3.	3.	3.	3.	3.	3.	3.	4.
20 - 24 ST	01.	2.	02.	3.	3.	4.	5.	6.	6.	7.	8.
20 - 24 ESDO	.	02.	2.	2.	1.	1.	1.	1.	1.	1.	1.
20 - 24 SSDO	.	6.	6.	7.	8.	9.	9.	10.	10.	11.	11.
20 - 24 O	547.	576.	593.	604.	617.	635.	659.	688.	721.	757.	794.
25 - 44 ES	8.	10.	11.	11.	12.	12.	12.	11.	11.	11.	10.
25 - 44 SS	11.	15.	17.	19.	21.	22.	23.	24.	025.	26.	27.
25 - 44 CS	33.	35.	38.	41.	45.	50.	56.	62.	68.	75.	82.
25 - 44 ET	10.	11.	11.	12.	12.	012.	13.	13.	13.	14.	14.
25 - 44 ST	13.	13.	13.	13.	14.	14.	15.	16.	17.	18.	20.
25 - 44 CT	6.	6.	7.	7.	7.	7.	8.	8.	8.	9.	9.
25 - 44 ESDO	.	.	1.	1.	1.	1.	1.	1.	1.	1.	1.
25 - 44 SSDO	.	1.	1.	1.	01.	01.	01.	01.	1.	1.	1.
25 - 44 O	2374.	2351.	2337.	2328.	2323.	2322.	2326.	2337.	2354.	2378.	2409.
44 + ET	5.	5.	6.	6.	6.	7.	7.	7.	8.	8.	9.
44 + ST	2.	02.	3.	3.	3.	4.	4.	4.	4.	5.	5.
44 + CT	6.	6.	7.	7.	7.	8.	8.	8.	9.	9.	9.
44 + O	2258.	2292.	2324.	2354.	2383.	2410.	2437.	2463.	2489.	2515.	2542.
Cumul. D	.	115.	232.	350.	470.	591.	713.	837.	961.	1087.	1215.

1/ Educational groups centered on academic year; "other" centered on April.

Table 6.-DYNAMOD II calculations of nonwhite female population groups, by age and educational category, 1959-60 to 1969-70[1/]
(Thousands)

age/ educational category	1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
0 - 4 ES	46.	54.	56.	56.	57.	57.	57.	56.	56.	56.	57.
0 - 4 O	1444.	1465.	1479.	1489.	1500.	1494.	1472.	1466.	1474.	1494.	1525.
5 - 14 ES	1966.	2136.	2208.	2283.	2356.	2425.	2488.	2543.	2590.	26[illegible]2.	2672.
5 - 14 SS	107.	127.	139.	145.	150.	155.	159.	163.	167.	170.	173.
5 - 14 ESDO	.	29.	32.	33.	34.	35.	36.	37.	38.	39.	39.
5 - 14 SSDO	.	1.	1.	01.	01.	01.	01.	01.	01.	1.	1.
5 - 14 O	318.	207.	219.	227.	232.	236.	238.	238.	239.	241.	245.
15 - 19 ES	68.	63.	61.	60.	61.	61.	62.	64.	65.	66.	67.
15 - 19 SS	372.	408.	452.	493.	527.	557.	584.	607.	628.	647.	664.
15 - 19 CS	38.	37.	38.	40.	43.	45.	48.	51.	53.	56.	58.
15 - 19 ESDO	.	13.	012.	012.	012.	012.	012.	13.	13.	13.	13.
15 - 19 SSDO	.	56.	62.	69.	75.	79.	83.	87.	90.	93.	96.
15 - 19 O	345.	254.	240.	239.	247.	258.	270.	283.	295.	306.	317.
20 - 24 ES	11.	10.	9.	8.	8.	7.	7.	7.	7.	7.	7.
20 - 24 SS	35.	26.	22.	20.	20.	20.	20.	21.	22.	22.	23.
20 - 24 CS	31.	41.	47.	51.	55.	58.	62.	66.	69.	73.	76.
20 - 24 ET	7.	6.	6.	6.	6.	7.	7.	7.	8.	8.	9.
20 - 24 ST	2.	02.	3.	3.	3.	4.	4.	4.	5.	5.	5.
20 - 24 ESDO	.	1.	01.	01.	01.	01.	01.	01.	01.	01.	01.
20 - 24 SSDO	.	14.	14.	15.	17.	18.	19.	19.	20.	21.	22.
20 - 24 O	620.	660.	696.	723.	751.	780.	812.	847.	884.	922.	960.
25 - 44 ES	11.	11.	11.	11.	11.	10.	10.	10.	9.	9.	9.
25 - 44 SS	24.	025.	24.	23.	22.	21.	21.	20.	20.	19.	19.
25 - 44 CS	17.	20.	23.	27.	30.	32.	34.	37.	39.	41.	43.
25 - 44 ET	36.	35.	34.	33.	33.	33.	33.	33.	33.	34.	34.
25 - 44 ST	11.	11.	10.	10.	10.	11.	11.	12.	012.	13.	13.
25 - 44 CT	4.	4.	4.	5.	5.	5.	5.	6.	6.	6.	6.
25 - 44 ESDO	.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
25 - 44 SSDO	.	02.	02.	02.	2.	2.	2.	2.	2.	2.	2.
25 - 44 O	2660.	2638.	2630.	2639.	2636.	2646.	2662.	2683.	2710.	2743.	2782.
44 + ET	20.	21.	21.	22.	22.	23.	23.	24.	24.	24.	025.
44 + ST	10.	10.	9.	9.	9.	9.	9.	9.	9.	9.	9.
44 + CT	2.	02.	02.	3.	3.	3.	3.	3.	4.	4.	4.
44 + O	2380.	2446.	2514.	2577.	2639.	2699.	2758.	2817.	2875.	2933.	2991.
Cumul. D	.	89.	180.	273.	368.	465.	563.	663.	765.	868.	974.

1/ Educational groups centered on academic year; "other" centered on April.

The present estimates of the number of secondary school dropouts by sex-race group is shown in figure 2. Figure 2 is a band chart. The number of dropouts in a particular group for a given year is indicated in the chart by the vertical distance within a particular band. Whites, who constitute the largest portion of the secondary school student population, also constitute the largest numbers of dropouts.

Under the present set of assumptions, the number of dropouts will continue to increase in time as the secondary school population increases. In the absence of effective policies counteracting the present trends, nonwhites will continue to have higher proportions of the dropout populations than they have of the school population.

Special Analyses

The special analyses presented below illustrate how DYNAMOD II can be of use to educational planners, analysts, and decisionmakers in three fields of study: impact analysis, policy sequencing, and structural studies. These are indicative, but by no means exhaustive, examples of the kinds of information yielded by the model.

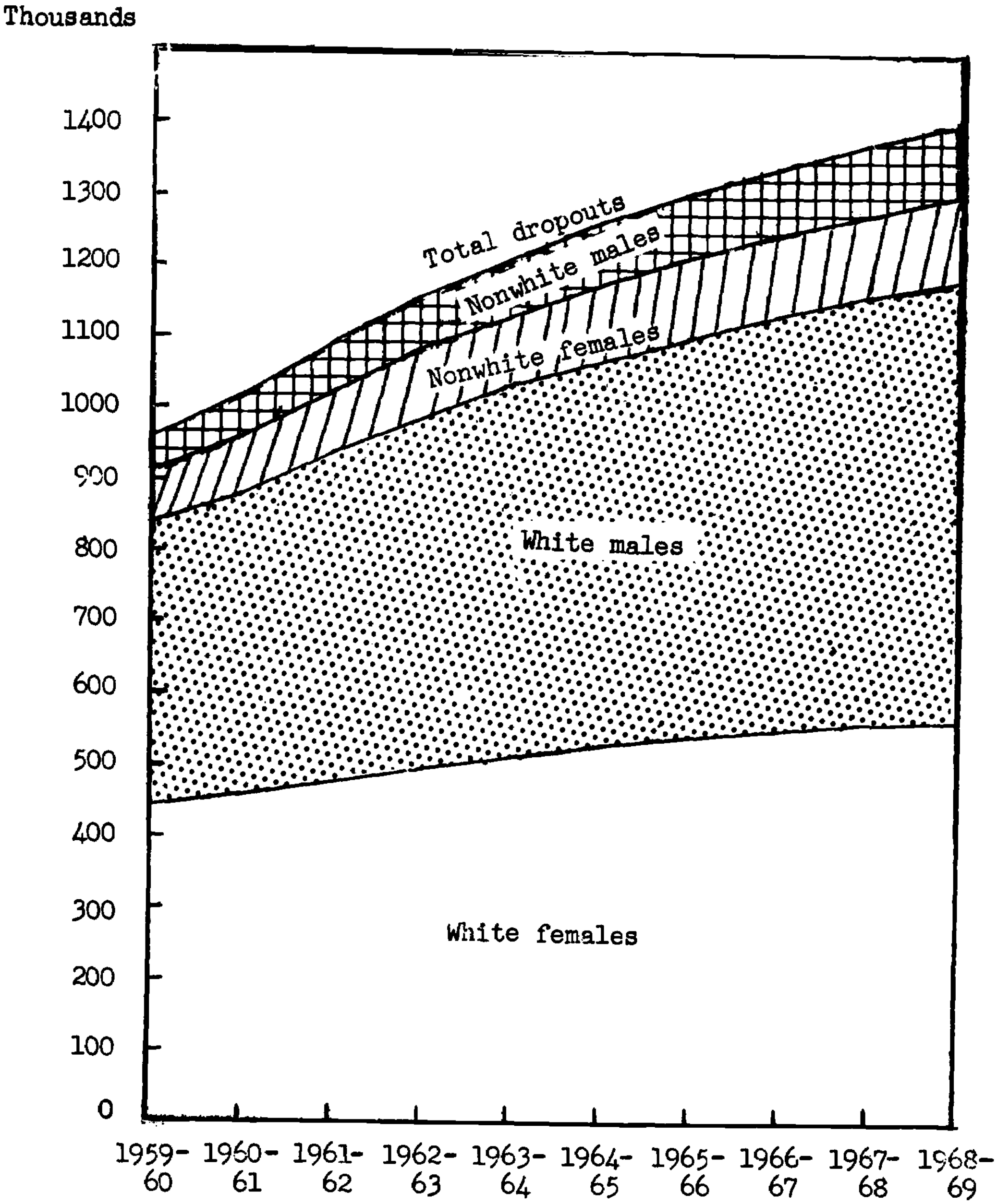
Impact analyses explore the effects of changes in the parameters of the model, e.g., birth rates or retention rates. Policy sequence analysis is concerned with obtaining feasible solutions to multiple (and sometimes apparently conflicting) policy objectives. Structural studies examine the network flows within the system described by the model and provide perspective on the relative importance of these flows.

Four topics in impact analysis will be considered. The first, birth variations, gives an indication of how changes in the number of births can affect the educational population over a period of time. The model originally was calibrated using the Bureau of the Census Series B birth data. Series D is a set of birth projections developed within the Division of Operations Analysis. Only one such variation is presented here, using Series D, but the figures can be varied to any degree desired.

The second, variations in retention rates serves a dual purpose. It shows the approximate changes in the composition of the educational population that might be expected by keeping a higher proportion of students or teachers in the system. It also indicates the effect of a one-percent error in a retention rate on the estimates of the population.

The third, secondary impacts of increasing student retention rates, traces the effects of changes introduced at one level of the system on other parts of the system. For example, anti-dropout

Figure 2 .-Secondary school dropouts by sex and race, 1959-60 to 1968-69



Source: Appendix table A-2

policies introduced at the secondary school level will affect future college enrollments and the number of teachers produced by the educational system.

The fourth, student-teacher ratios, probes some of the possible outcomes of pursuing such mixed policies as, for example, introducing programs to keep more students in the system without introducing companion programs aimed at increasing teacher retention rates.

Birth variations.- The ultimate validity of any set of population projections is known to be highly dependent on the agreement between actual and assumed numbers of births. Sudden shifts in the birth rate of the population caused by the outbreak of war, business conditions, new birth control devices, or from whatever source, can have marked effects on projections of the numbers of people in various categories of interest.

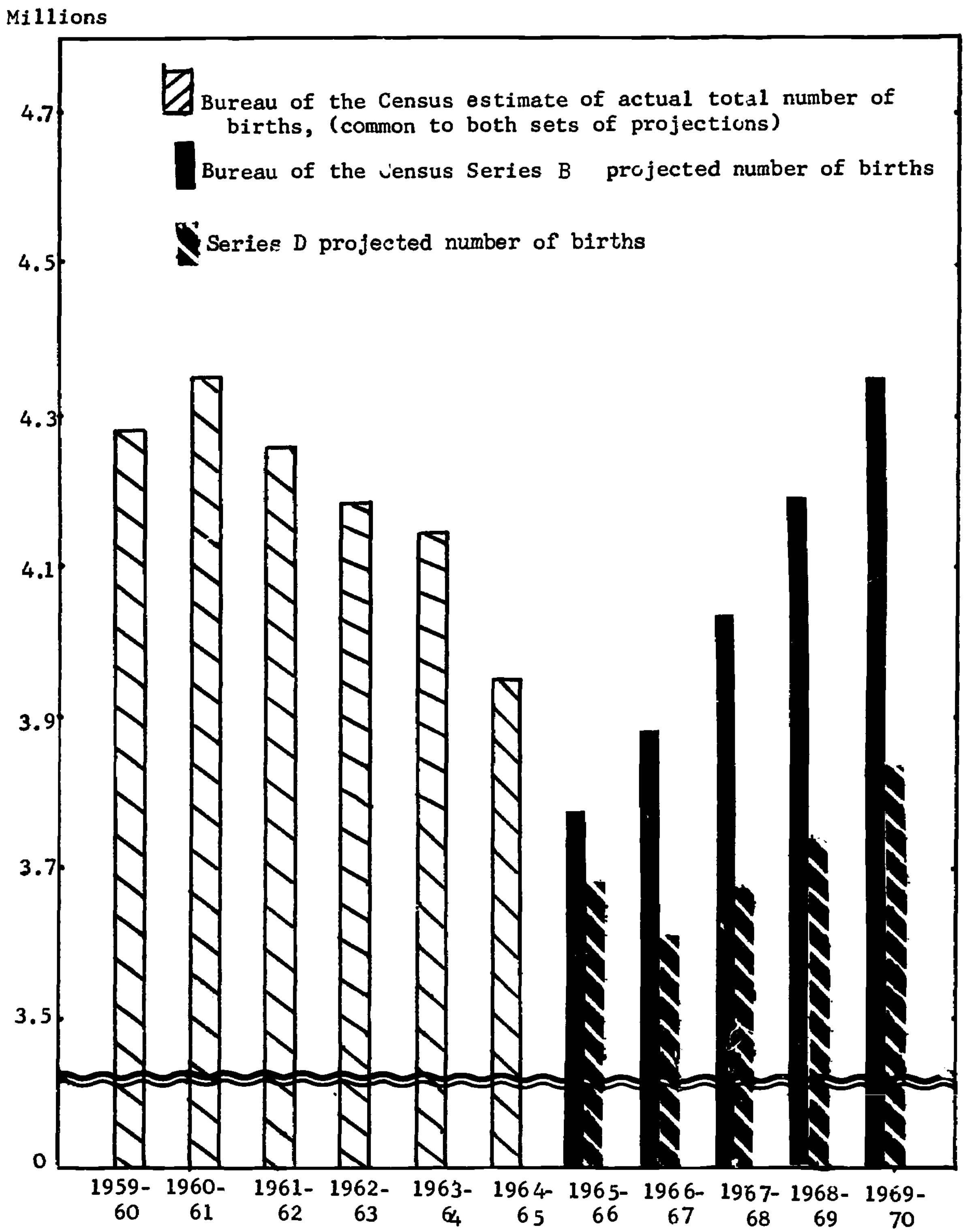
It is a great convenience in a population-projections model to have the flexibility of easily changing the assumed birth rates.4/ For example, educational planners and analysts are free to postulate any desired impact on the birth rate of a policy emanating within or outside of the educational system, and they can then obtain an estimate of the impact on the educational population as a result of the postulated policy.

Presented below is an example of the population effects caused by using different assumptions regarding births. Note in figure 3 that the birth data for the years 1959-60 through 1964 are common to both sets of calculations. For those years, estimated actual birth data were available, and therefore were used. For the remaining years in the calculation interval, estimates from Series B or Series D were used.

As may be expected, differences arise in the calculated (1966-70) population figures according to the particular type of birth figures used as inputs. Projections of population groups based on the higher Series B birth projections show up consistently higher than the calculations resulting from DYNAMOD II birth estimates. In certain age groups, differences in the projected population group totals become more pronounced with the increased number of years in the calculation interval.

4/ The same may be said for death rates.

Figure 3. Series D and Series B birth data used in DYNAMOD II, 1959-60 to 1969-70



Source: Appendix table B-1 and Technical Note No. 11

The 0-4 year old age group shows the greatest difference, amounting to 1.3 million by the year 1970 (figure 4). It may be noted that the higher birth rates from Series B births in the 0-4 year old group are reflected following the year 1966 in the totals for the 5-14 year olds (figure 5). This is due to an artifact in the model caused by the use of groupings, instead of using single years of age: a small proportion of the increased population of 0-4 year olds is transferred to the 5-14 year group during one cycling of the data because of the age transition probability coefficient. This artifact will be avoided in future network flow models such as STAG by using single years of age. Differences due to increased Series B births, however, are not reflected beyond the 15-19 years group because of the short length of the calculational span (figure 6).

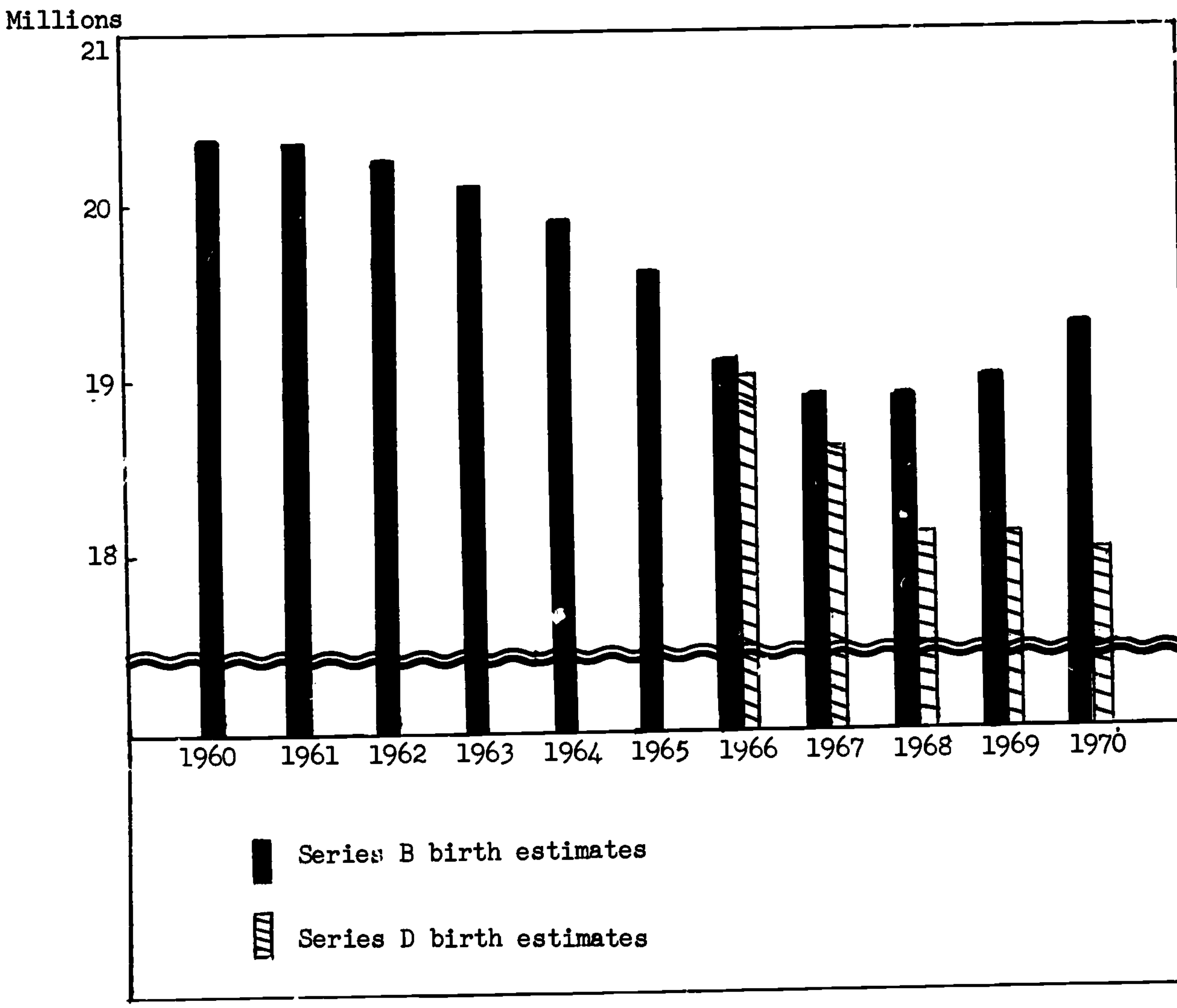
Among the student groups, the assumed differences in birth rates affect only elementary and secondary school students, i.e., there is no effect on the number of college students introduced by the higher number of births in Series B, because the period of calculation is only five years (appendix table B-3). Obviously, however, if the population had been calculated for a greater number of years, effects of birth variations would ultimately be felt in all age groups.

For the calculations to 1970 by race, the births resulting from the use of Series B estimates show an excess of 1.4 million whites and 323,000 nonwhites over those using Series D births, or a difference of 0.8 percent and 1.3 percent respectively (appendix table B-4).

For male and female calculations, differences amount to 866,000 males (0.9 percent) and 830,000 females (0.8 percent) by the year 1970, (appendix table B-5).

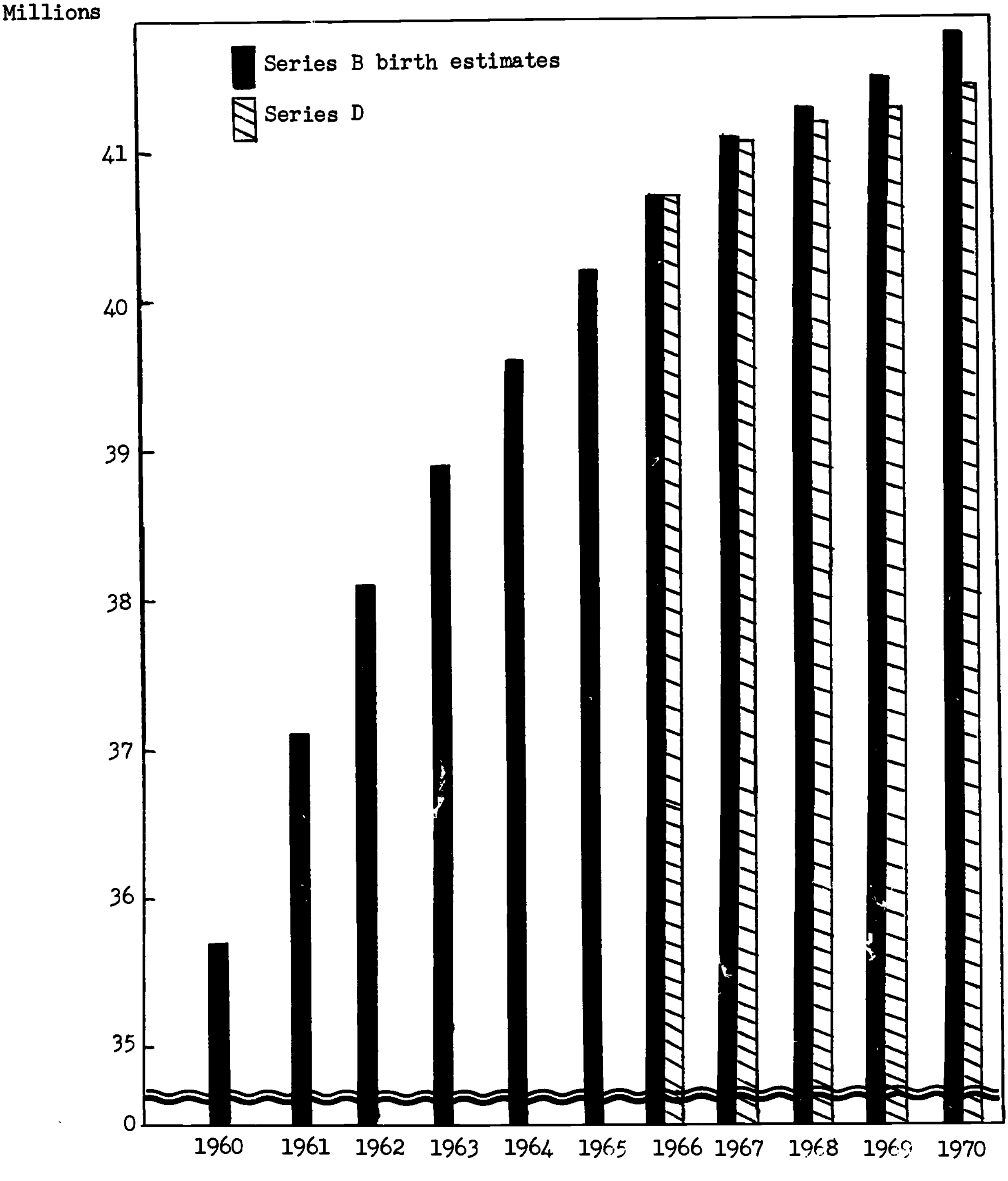
Variations in student and teacher retention rates. Varying the retention rates for students and teachers consisted of increasing by one percent the probability that a student or teacher would remain in his respective educational category from one year to the next. Thus, if a retention rate (transition probability) was .8000 in the original DYNAMOD II projection, it was changed to .8080, or by one percent. Now, because the row values in the transition matrix had to add to 1.0000, the increment (.0080) had to be taken from among the remaining row entries. It was decided to take the balance from the dropout or "other" categories, whichever was appropriate, since by so doing, the remaining structure of the educational system would not be directly affected. Basically, then, the effect of an increase in a retention rate is to keep more individuals in a given category without altering materially the flows of those remaining within the educational system.

Figure 4.- Comparison of DYNAMOD II population calculations of 0-4 year olds, using different birth estimates, 1960-1970



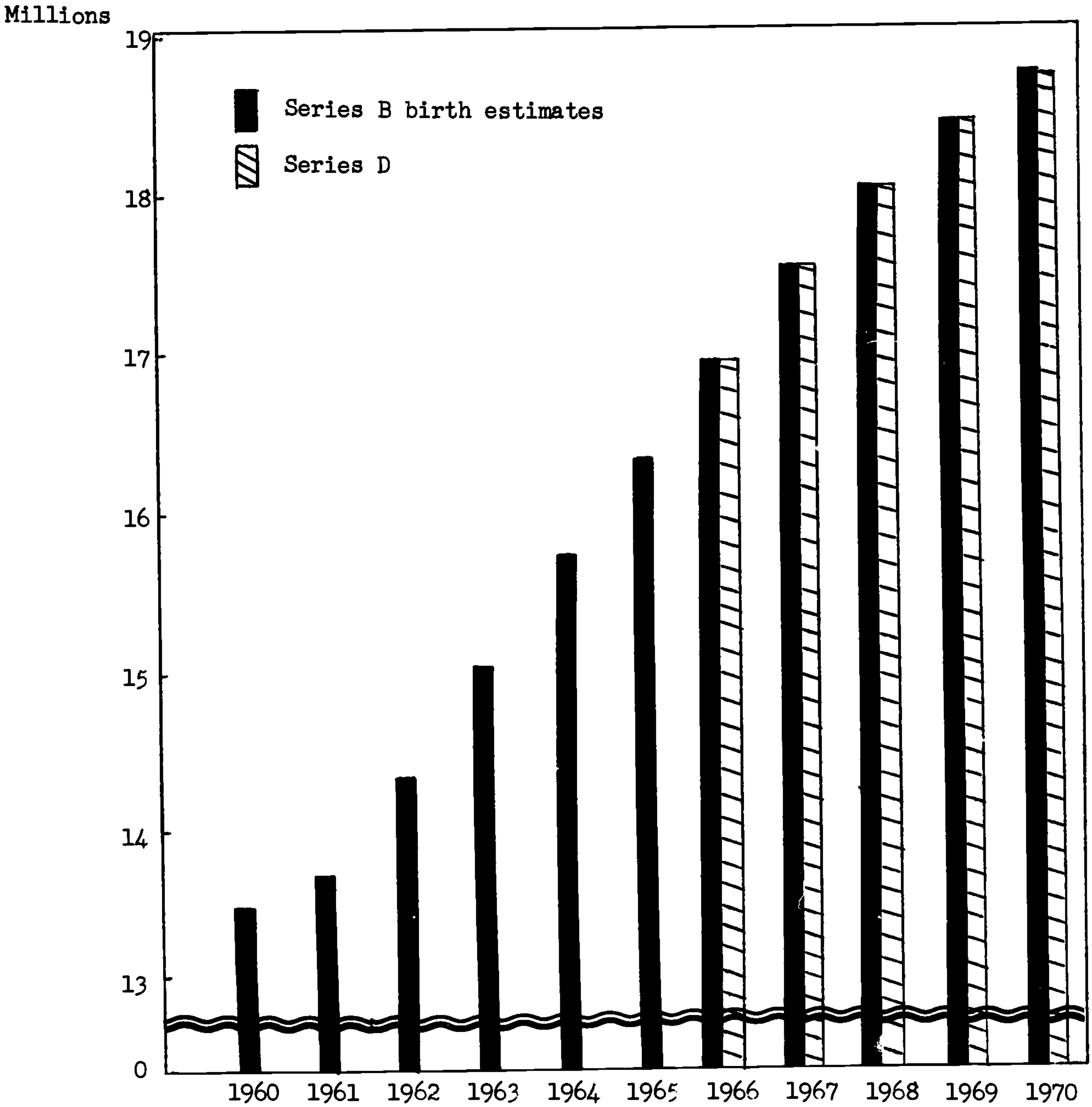
Source: Appendix tables A-4 and B-2

Figure 5.- Comparison of DYNAMOD II population calculations of 5-14 year olds, using different birth estimates, 1960-1970



Source: Appendix tables A-4 and B-2

Figure 6.-Comparison of DYNAMOD II calculations of 15-19 year olds using different birth estimates, 1960-1970



Source: Appendix tables A-4 and B2

The increases in the rates were made one at a time, to avoid confounding the effects of the changes.

The effect of increasing the <u>elementary school student retention rate</u> by one percent was to raise the level of the calculation for the 1969-70 school year from about 37.0 million to slightly over 37.5 million, or by 1.3 percent (figure 7). The relative impact of increasing the elementary school student retention rate, that is, the percent increase in students over the base line projection, was lowest for elementary school students, remaining near one percent over the entire projection interval. Furthermore, the "time to maximum response," i.e., the time required to reach the maximum relative difference over the base line projection was shortest for this group, reaching the maximum level (1.3 percent) within 4 years.

Knowledge of the relative impact of changes in the educational population can be of great aid to educational planners, analysts and decisionmakers by providing them with information regarding required changes in the capacity of the system resulting from the implementation of policies that change the numbers of students or teachers in the system. For example, if planners estimate their capacity requirements on the basis of a given set of flow rates for students and teachers, they will be interested in learning what additional changes in capacity may be required by policies that affect the retention rates of students. In the case of elementary school students, for example, an increase of one percent in the retention rate would require capacity in the system sufficient to handle the original projections plus about 1.2 to 1.3 percent more each year in the interval.

However, for secondary school students, the requirements are somewhat higher. A 1- percent increase in their retention rate would raise the DYNAMOD II calculation for 1969-70 from about 13.8 million to over 14.1 million students, or 2.1 percent (figure 8). That is, for each 1.0-percent increase in the retention rate, an enrollment increase equal to original projection plus an additional 2.1 percent could be expected within 10 years.5/ Not all the relative impact would be

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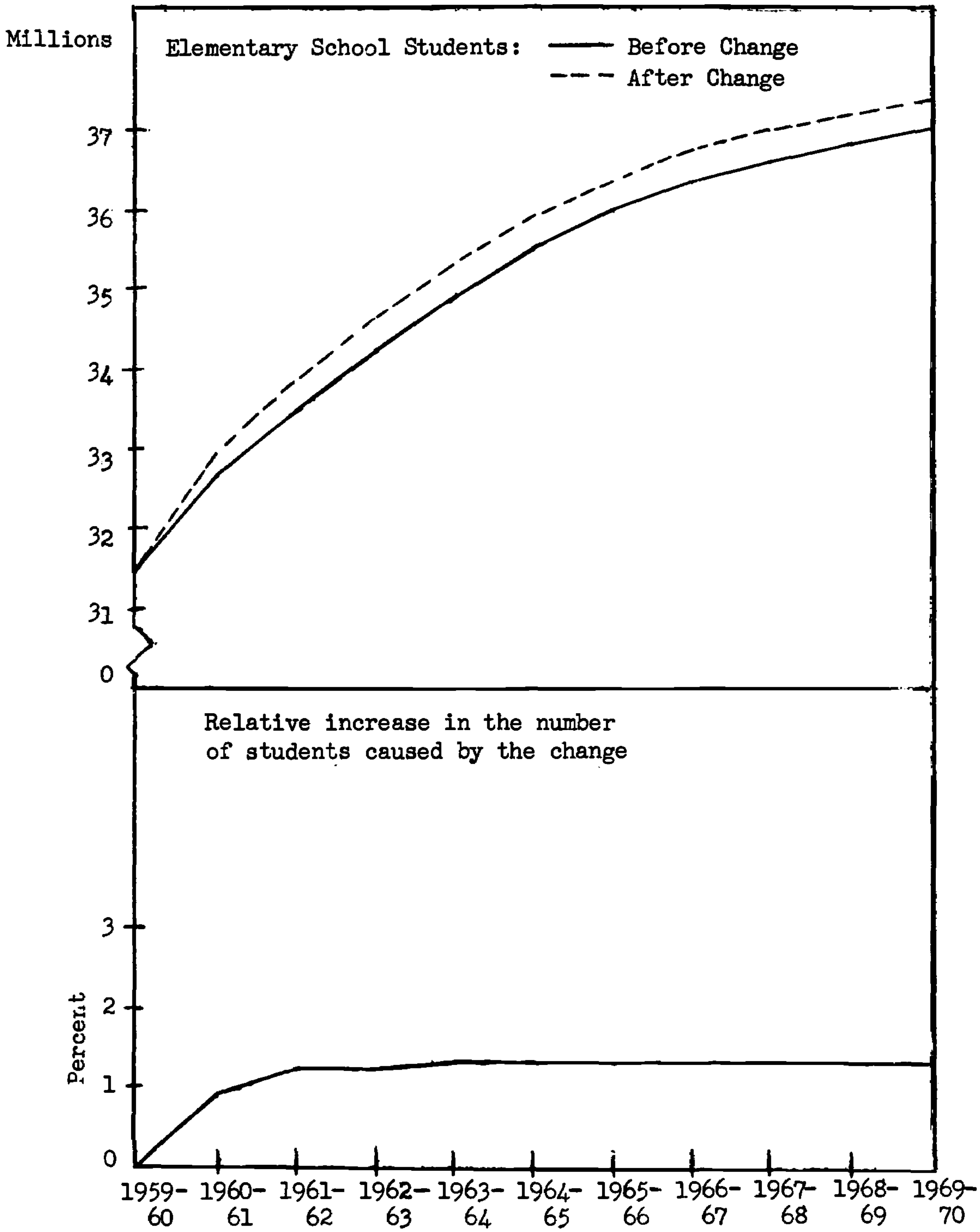
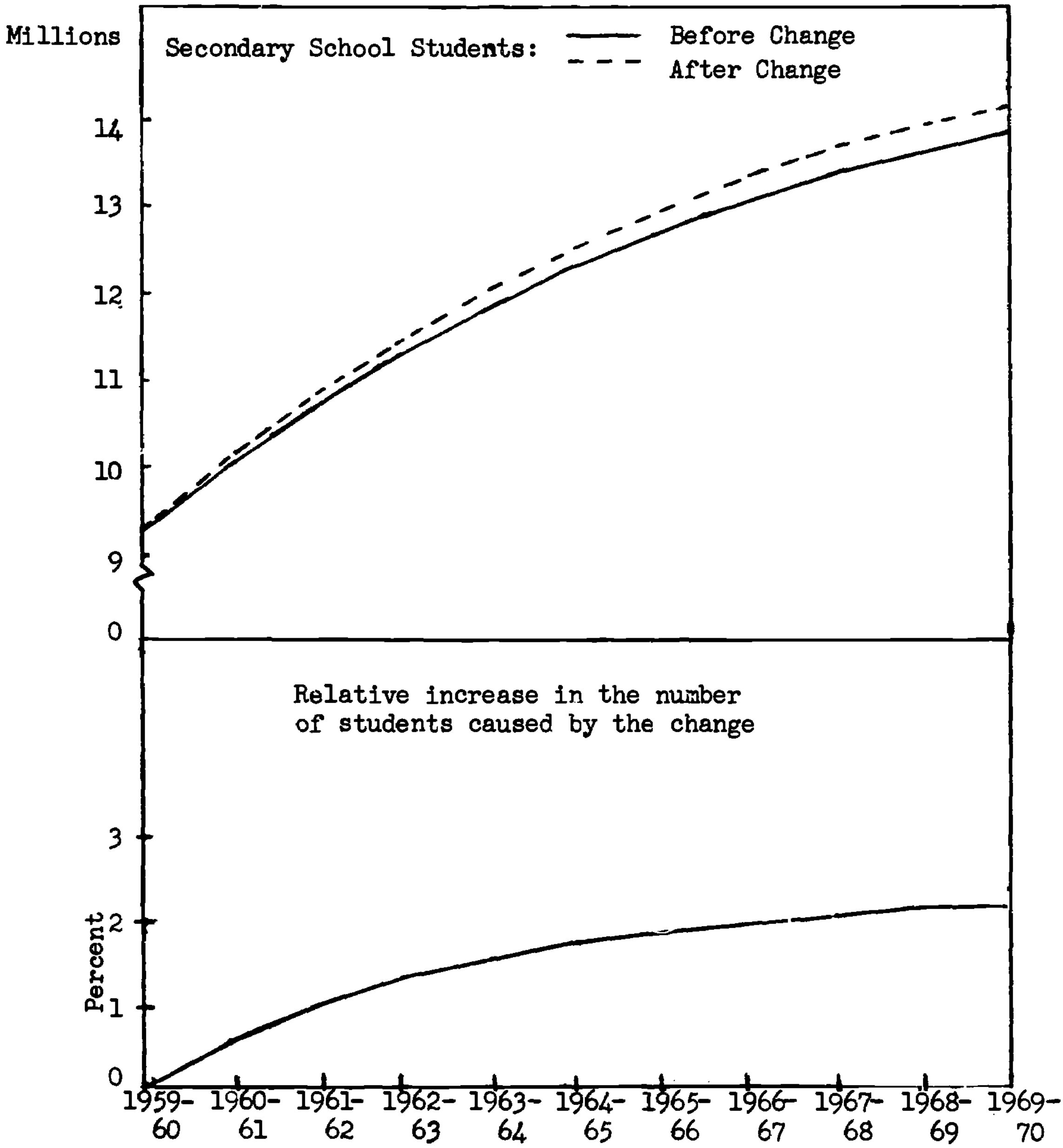
5/ There are obvious limits to such a statement. First, if the required capacity were not available, then there simply would not be room for that many students. Second, the changes discussed here are marginal (small) changes, and may not be applicable over large ranges of possibilities. For example, a change of 10 percent in the retention rate may not require places for an additional 21 percent enrollment in 10 years.

Figure 7. -Results of a one percent increase in the elementary school student retention rate, 1959-60 to 1969-70



Source: Appendix table C-1

Figure 8. -Results of a one percent increase in the secondary school student retention rate, 1959-60 to 1969-70



Source: Appendix table C-2

expected immediately, as the graph of the relative increases indicates. By the 1964-65 school year, for example, the increased requirements are about 1.7 percent higher than for the original projections.

As might be expected, there are limits to the relative impacts of policy changes. From the structure of DYNAMOD II, it appears that the maximum relative impact on the number of secondary school students is about 2.4 percent, reached in about 12 years from the implementation point.6/

The greatest relative impact of all three student categories is achieved with college students (figure 9), where the figure becomes 3.0 percent by 1969-70, with an apparent maximum of 3.3 percent in about 15 years. While this group has the largest relative response to retention policies, the absolute effect by the end of the 10-year projection interval is smallest, being only 194 thousand students above the original 1969-70 DYNAMOD II projection of 6.6 million students.

The teaching sector appears to be much more sensitive to increases in the retention rates than is the student sector, although, of course, the absolute numbers of persons involved are much smaller than is the case for students. The effects of increasing the retention rates for teachers are shown in figures 10, 11 and 12. The relative response factors are quite high by the end of the 10-year interval, being 4.8 percent for secondary school teachers, and close to 6 percent for elementary school and college teachers, respectively.

Effective policies aimed at increasing the holding power for teachers in the system, then, would appear to be particularly desirable means of increasing the total population of teachers. This seems to be especially true for college teachers, where a heavy dependence on returns from the "other" category is required to maintain an acceptable number in the system.

Those who are engaged in impact analysis might well ask about the ability of the system to handle changes much larger than one percent. DYNAMOD II cannot answer this question directly. The capacity of the systems to handle changes in the numbers of people flowing through it must presently be handled outside of the model. This is not without its advantages, however. The ability to calculate the ramifications of policy changes independently of considerations of the system's capacity provides a measure of what the economist calls an "opportunity cost." That is, for example, if an otherwise acceptable policy change

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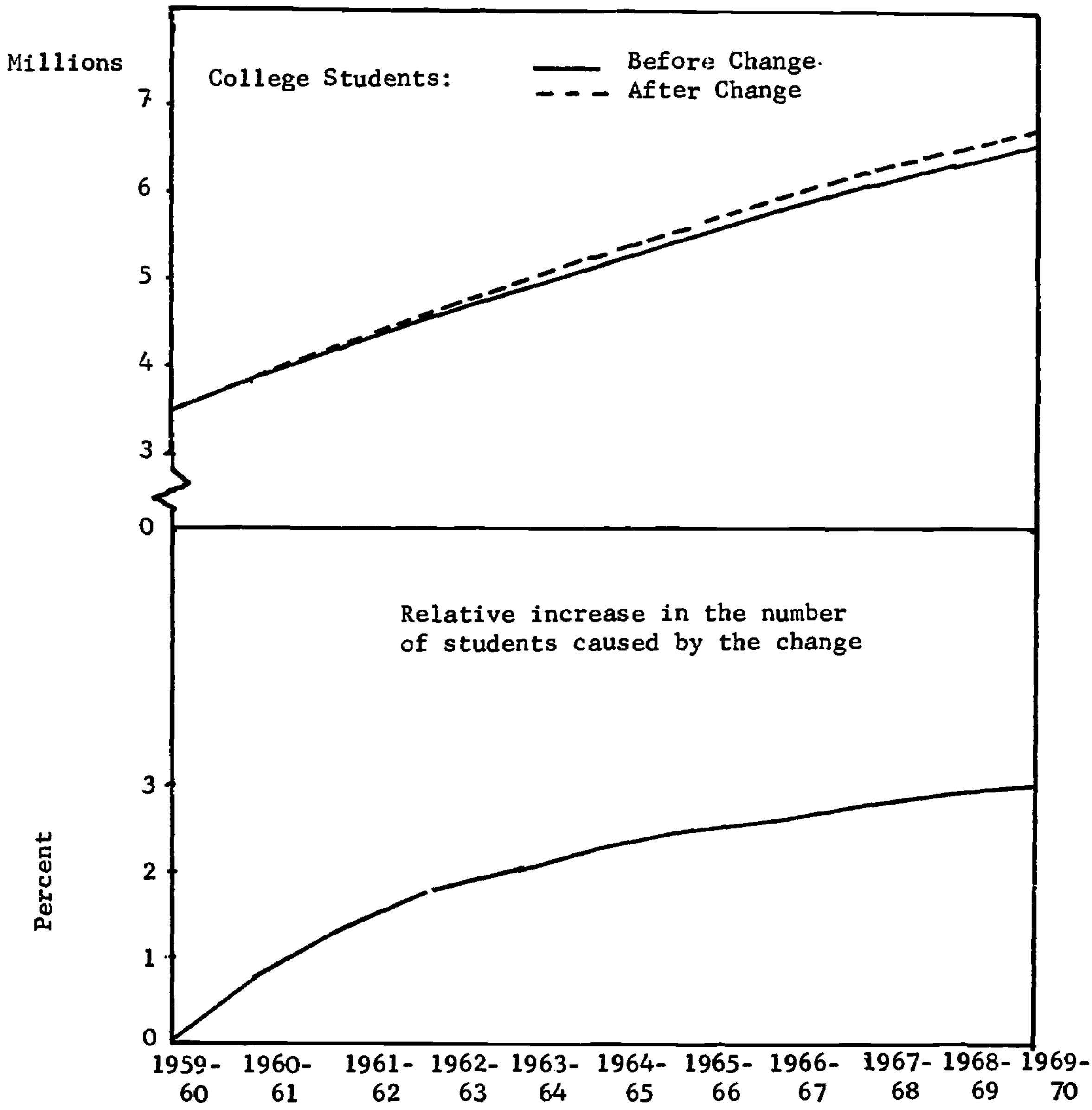
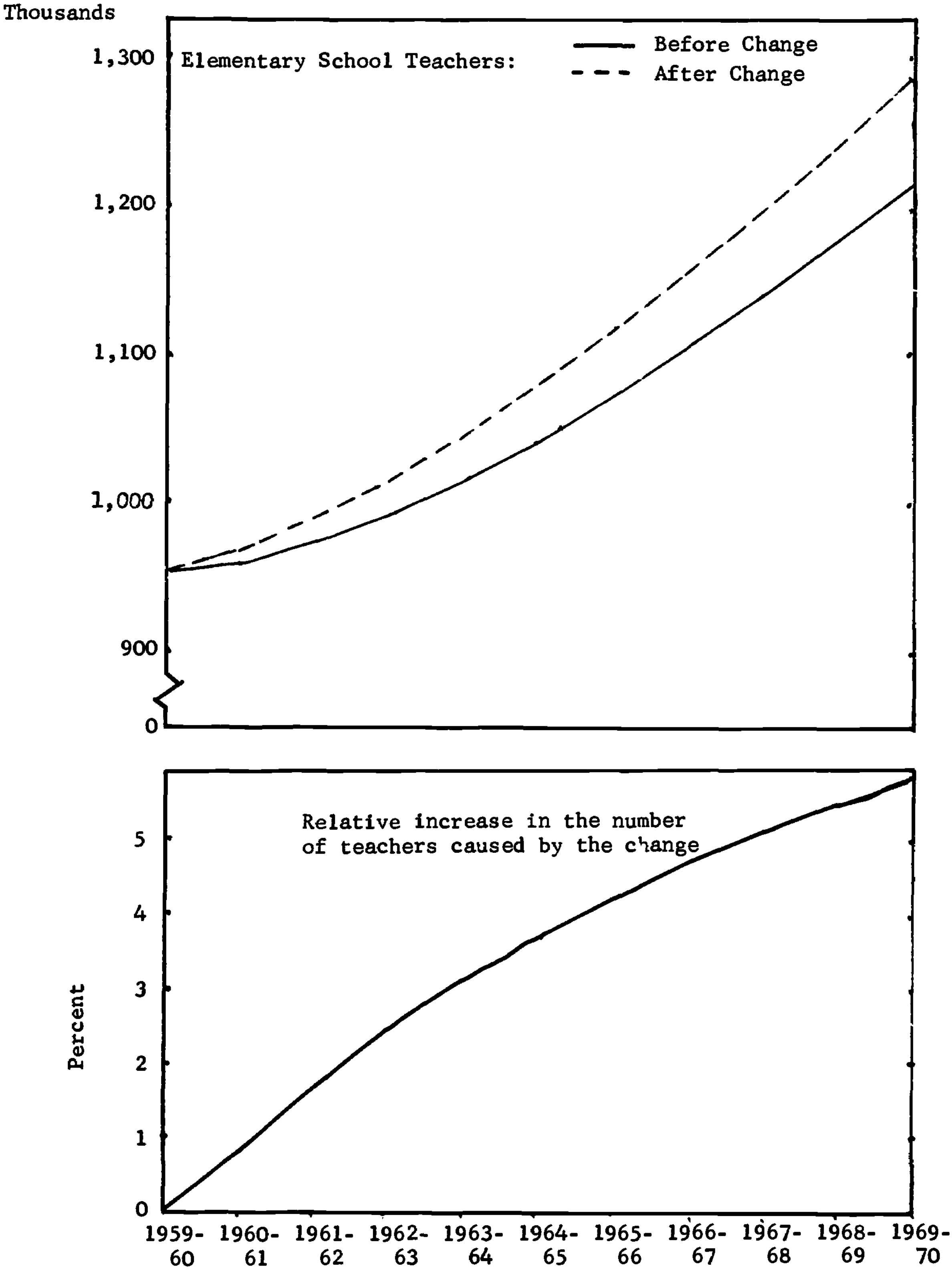
6/ The 12-year figure is an estimate taken from the chart, and is not the result of a statistical fit of the data.

Figure 9. -Results of a one-percent increase in the college student retention rate, 1959-60 to 1969-70



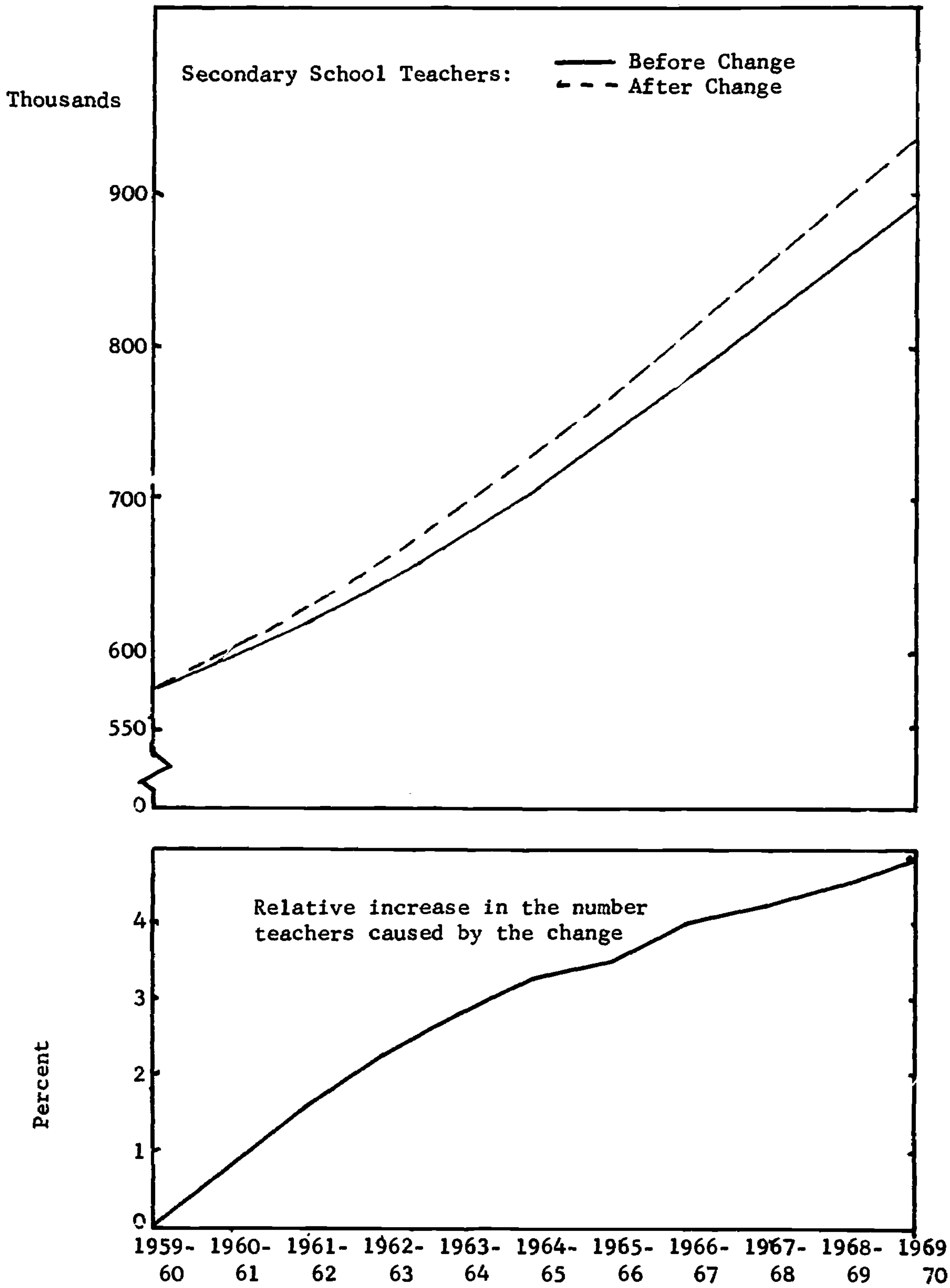
Source: Appendix table C-3

Figure 10.-Results of a one-percent increase in the elementary school teachers' retention rate, 1959-60 to 1969-70



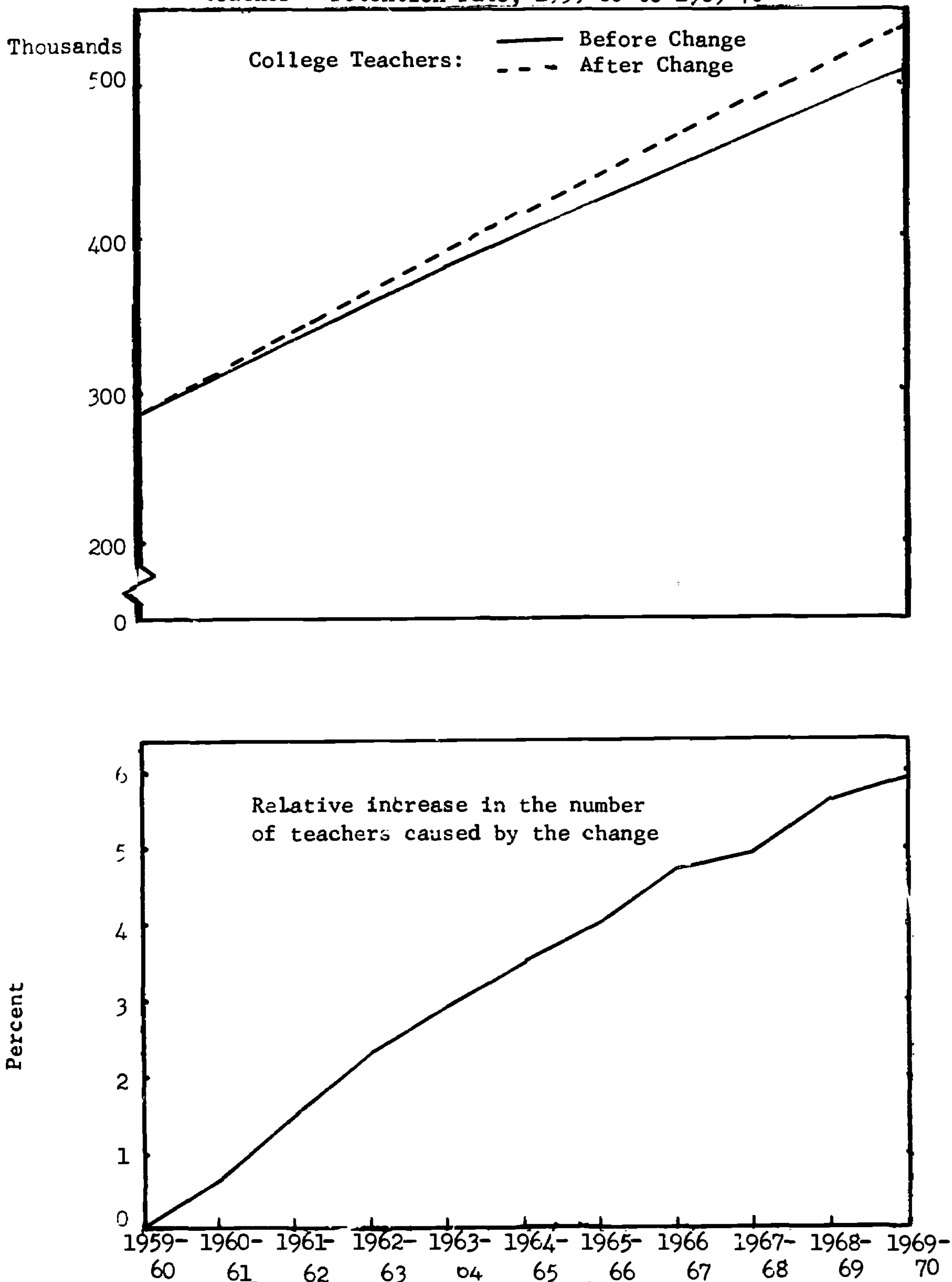
Source: Appendix table C-4

Figure 11.-Results of a one-percent increase in the secondary school teachers' retention rate, 1959-60 to 1969-70



Source: Appendix table C-4

Figure 12.-Results of a one-percent increase in the college teacher retention rate, 1959-60 to 1969-70



Source: Appendix table C-4

would produce more college graduates than the system could handle, then an opportunity cost is incurred in terms of foregone college graduates amounting to the economic value of the difference in the number of graduates that could be obtained and those actually expected.

Secondary impacts of increasing student retention rates. Policies aimed at changing the rates of flows in one sector are not necessarily confined to that sector. For example, a policy designed to increase the retention rate (or, the same thing, decrease the dropout rate) of secondary school students will eventually be reflected in the flows to college study and later into teaching.

A special analysis of the secondary impacts of changes to the retention rates of a given level of schooling (elementary, secondary, and college) was conducted. Three computer runs were executed. In each computer run, the retention rates for the sector of interest were increased by one percent beginning with the 1959-60 academic year. The results are shown in figures 13, 14 and 15.

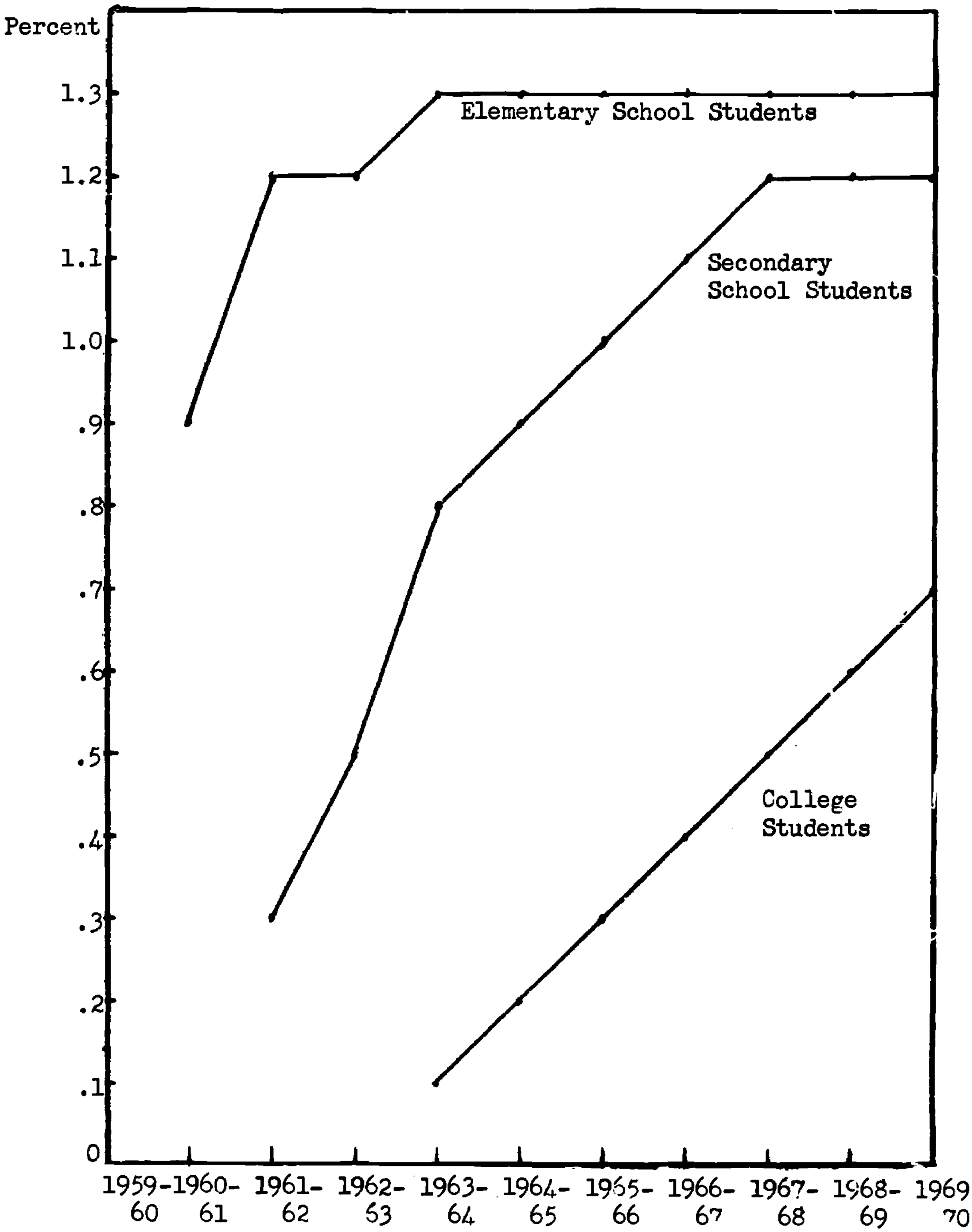
For a one percent increase in the retention rates of elementary school students in 1959-60, the impact on the population of secondary school students would have been an increase over the original DYNAMOD II calculations amounting to .3 percent in 1961-62 and growing to 1.2 percent by 1969-70. By 1969-70, the impact on the college student sector would have been .7 percent. Very little impact on the teaching sector was recorded because of the short period of time spanned by the calculations.

For a one percent change in the retention rate of secondary school students, the resulting increase in college student enrollments would have risen from .3 percent in 1961-62 to 2.3 percent by 1969-70. The impact on the teaching sector would have been small, in 1969-70 reaching .3 percent for elementary school teachers, .4 percent for secondary school teachers, and a negligible amount for college teachers.

Increasing the retention rate of college students by one percent in 1959-60 would have increased the number of elementary school teachers by one percent in 1969-70. In the same year (1969-70), the number of secondary school teachers would have risen by 1.4 percent, and college teachers by .6 percent over the original DYNAMOD II calculations.

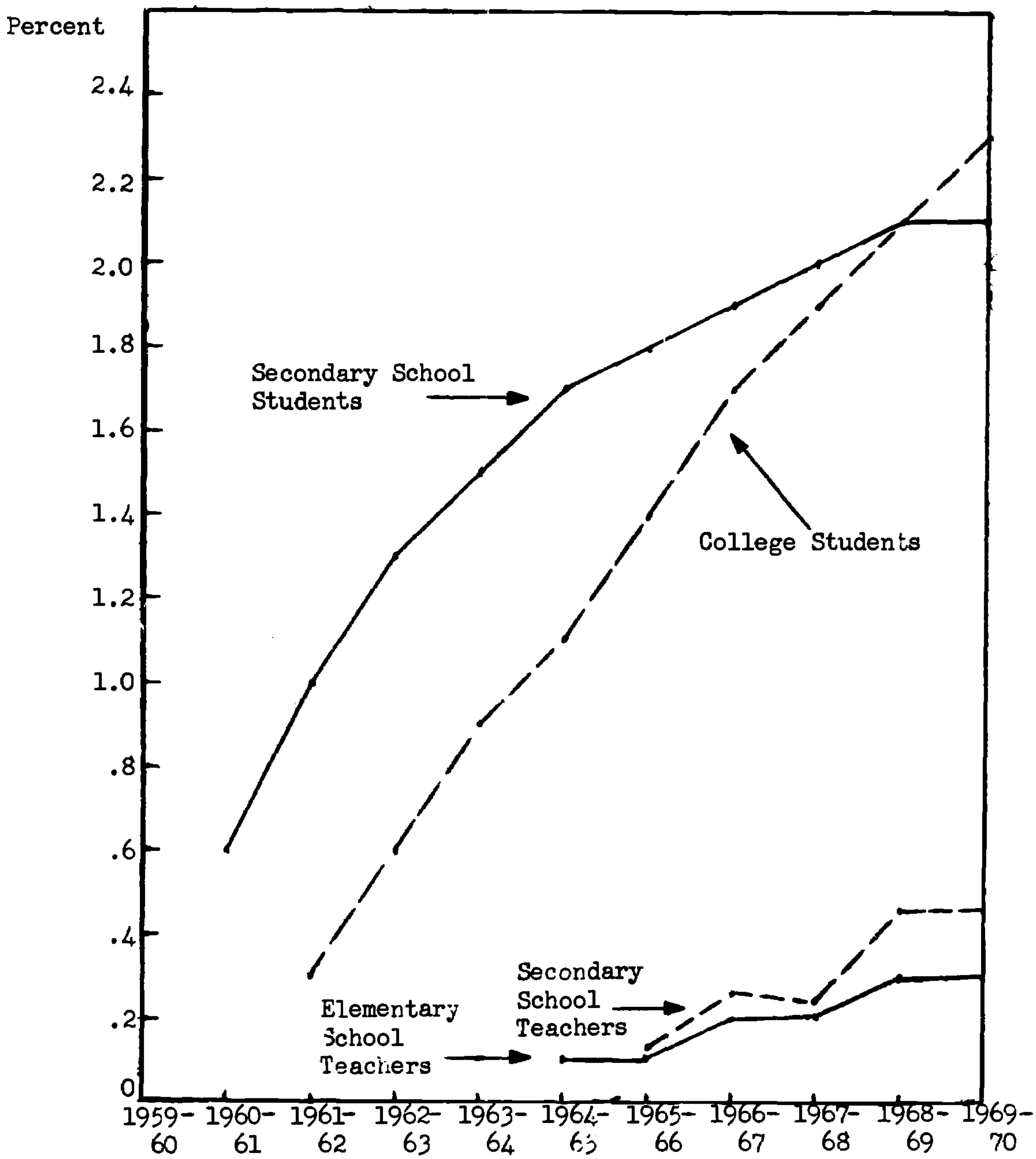
Student-teacher ratios. One of the frequently used measures of the "load" on parts of the educational system is the student-teacher ratio. Although the accepted range of variation of this ratio is a frequent and unresolved matter of discussion, the fact that it is frequently discussed and published in educational literature suggests that, despite its limitations, it is a tool of planning and policy-making.

Figure 13.-Relative increases in the educational population brought on by a one-percent increase in the DYNAMOD II elementary school student retention rate, 1959-60 to 1969-70



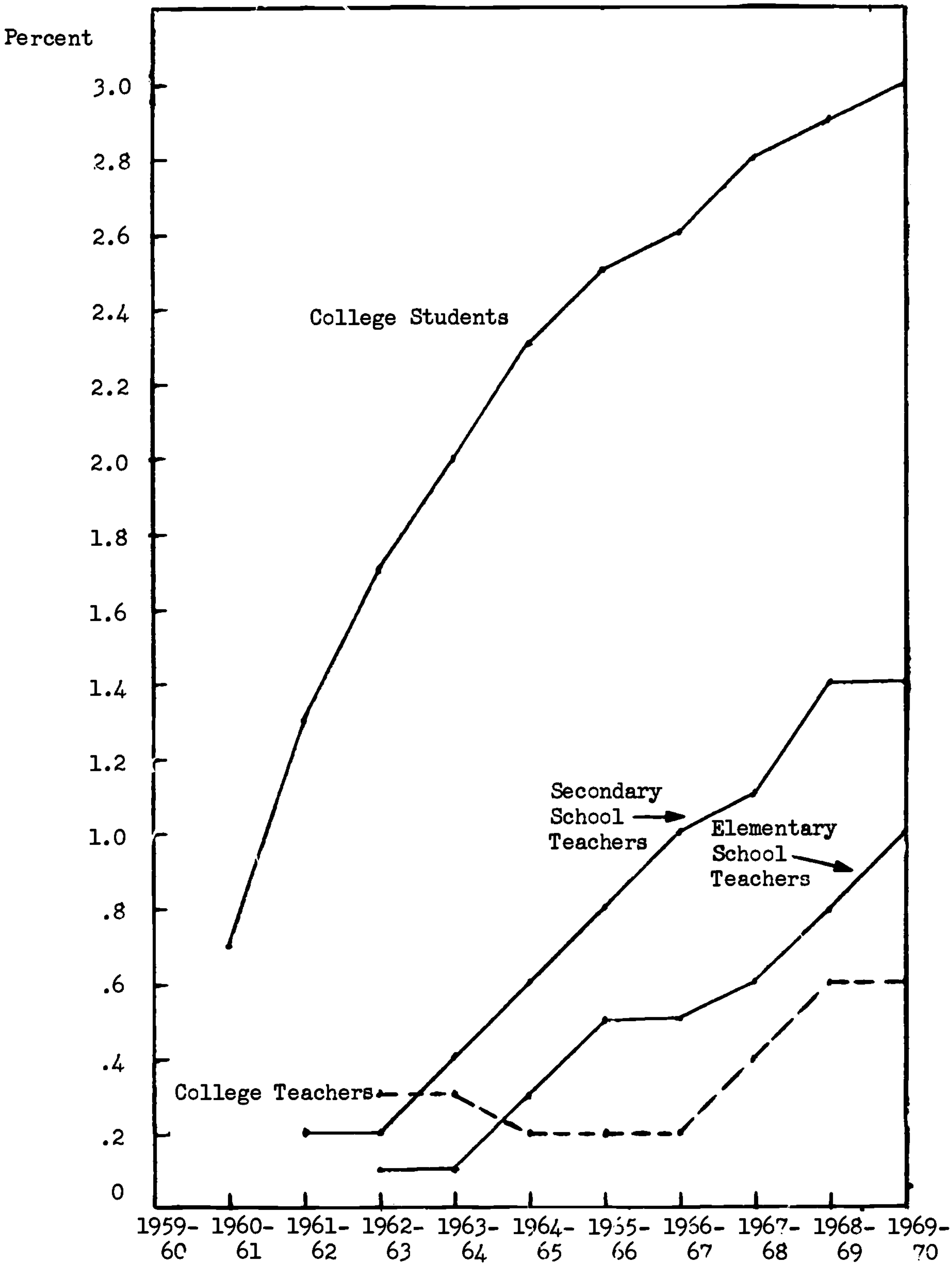
Source: Appendix table C-1

Figure 14.-Relative increases in the educational population brought on by a one-percent increase in the DYNAMOD II secondary school student retention rate, 1959-60 to 1969-70



Source: Appendix table C-2

Figure 15.-Relative increases in the educational population brought on by a one-percent increase in the DYNAMOD II college student retention rate, 1959-60 to 1969-70



Source: Appendix table C-3

This being the case, one consideration of the impact of policy changes on retention rates within the system should be the effect of those changes on the student-teacher ratios in the respective levels of the educational process.

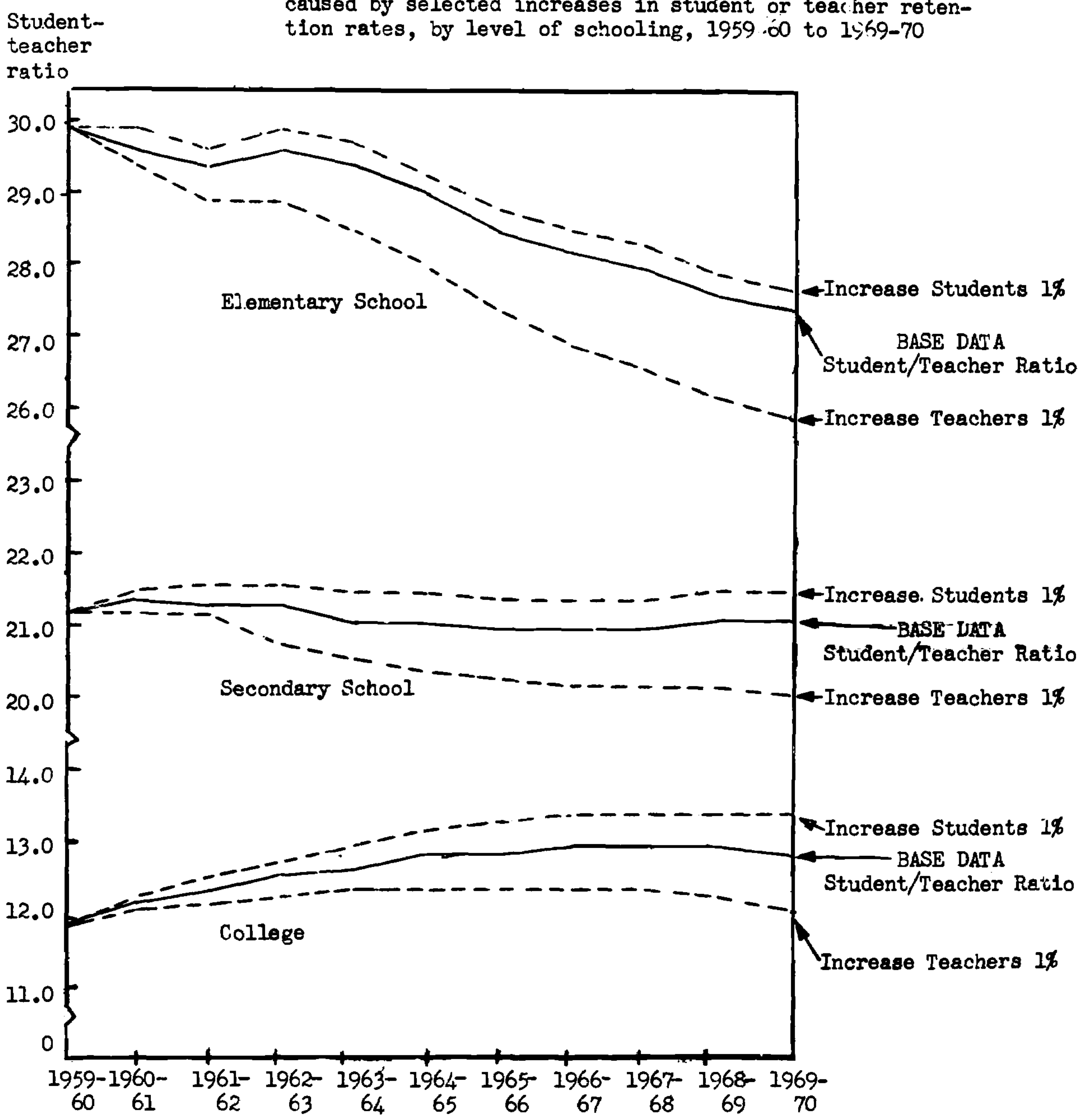
For example, it might seem intuitively desirable to increase the retention rates of all students, because of the belief that a better educated population is more productive, and that economic well-being increases with productivity. However, if an increase in the number of students processed within the system comes about at the expense of unacceptably high student-teacher ratios, the quality of the education received by the students, hence their productivity, may in fact be less than would have been the case had the policy not been implemented.

Consider another planning problem. Suppose policymakers are in agreement that (1) a particular student-teacher ratio is too high, and (2) the proper policy to follow to lower it is to increase the retention rate of teachers in the system. How much should the rate be changed to meet predetermined objectives?

DYNAMOD II can be of use in cases such as these. To illustrate the model's utility, student-teacher ratios are presented in this section in a manner that reflects a range of outcomes of policy alternatives. The student-teacher ratios calculated from base line data are contrasted with the ratios resulting from increases in the student retention rates with the teacher rates unchanged, as well as with the converse, i.e., the student retention rates unchanged with the teacher retention rates increased. All increases in the retention rates were one percent.

The results of these calculations are shown in figure 16. As can be inferred from the chart, two important patterns are present. First, the policy of increasing the retention rates of students without changing the retention rates of teachers has its greatest percentage impact on the college student-teacher ratio and least affects the elementary school student-teacher ratio. Second, a one percent increase in the retention rates of teachers has a very strong effect on the ratios, lowering all three from between 4.8 to 5.9 percent by the 1969-70 academic year, as highlighted in the discussion table below:

Figure 16.-Comparison of the variations in the student-teacher ratio caused by selected increases in student or teacher retention rates, by level of schooling, 1959-60 to 1969-70



Source: Appendix table D-1

An increase of one percent in the retention rate of:	Produces a percent difference in the base line student-teacher ratio approximately equal to: 1964-1965	1969-1970
Elementary school students	1.3	1.3
Secondary school students	1.7	2.1
College students	2.3	3.0
Elementary school teachers	-3.7	-5.8
Secondary school teachers	-3.3	-4.8
College teachers	-3.5	-5.9

The data in appendix table D-1 indicate that, for the college sector, either alternative of increasing the student retention rate or the teacher retention rate by one percent will be associated with an absolute increase in the student-teacher ratio over the middle range of the projection interval. This is a pure population effect caused by the enlarged college enrollments, and is sufficient to offset the effects of small increases in the number of college teachers. This suggests that if the desired policy is ultimately to increase the number of students, in the system over the base line projections, one way of minimizing the impact on the student-teacher ratio is to sequence the operations: first to pursue policies that will retain more teachers in the system, and then take the desired action to increase the retention rates of students. (See "Policy sequencing" below).

Examining the data in more detail it can be noted that, even though more students enter the system each year at the elementary school level, the projected number of elementary school teachers increases at a faster rate than the students, lowering the student-teacher ratio from 29.9 in 1959-60 to 27.8 in 1969-70. In the secondary school sector, little change is noted over the interval.

If a one-percent increase is made in the retention rates of secondary school students the relative difference in the student-teacher ratio over the base line ratios is slightly greater than for the elementary school sector. A one-percent increase in the retention rate for college students increases the student-teacher ratio from a base line value of 12.9 to 13.3 in the 1969-70 academic year.

For elementary school teachers, an increase of one percent in their retention rate implemented in 1959-60 would have decreased the student-teacher ratio from 27.4 to about 25.9 by 1969-70.

The same type of change in the retention rate of secondary school teachers reduces the 1969-70 secondary school student-teacher ratio from 21.1 to 20.1 (a decrease of about 4.7 percent), while for college teachers, the one percent change reduces the student-teacher ratio from 12.9 to 12.1 or a decrease of 6.2 percent.

Policy sequencing.- DYNAMOD II also can be helpful in determining how policies may be sequenced. Consider a problem involving the retention of elementary school students in the system, and have this policy interact with a policy concerning student-teacher ratios. If retention rate increase policies are pursued without restriction, then without compensating increases in the number of teachers some retention policy would exceed the limits of the national notion of the acceptable student-teacher ratio.

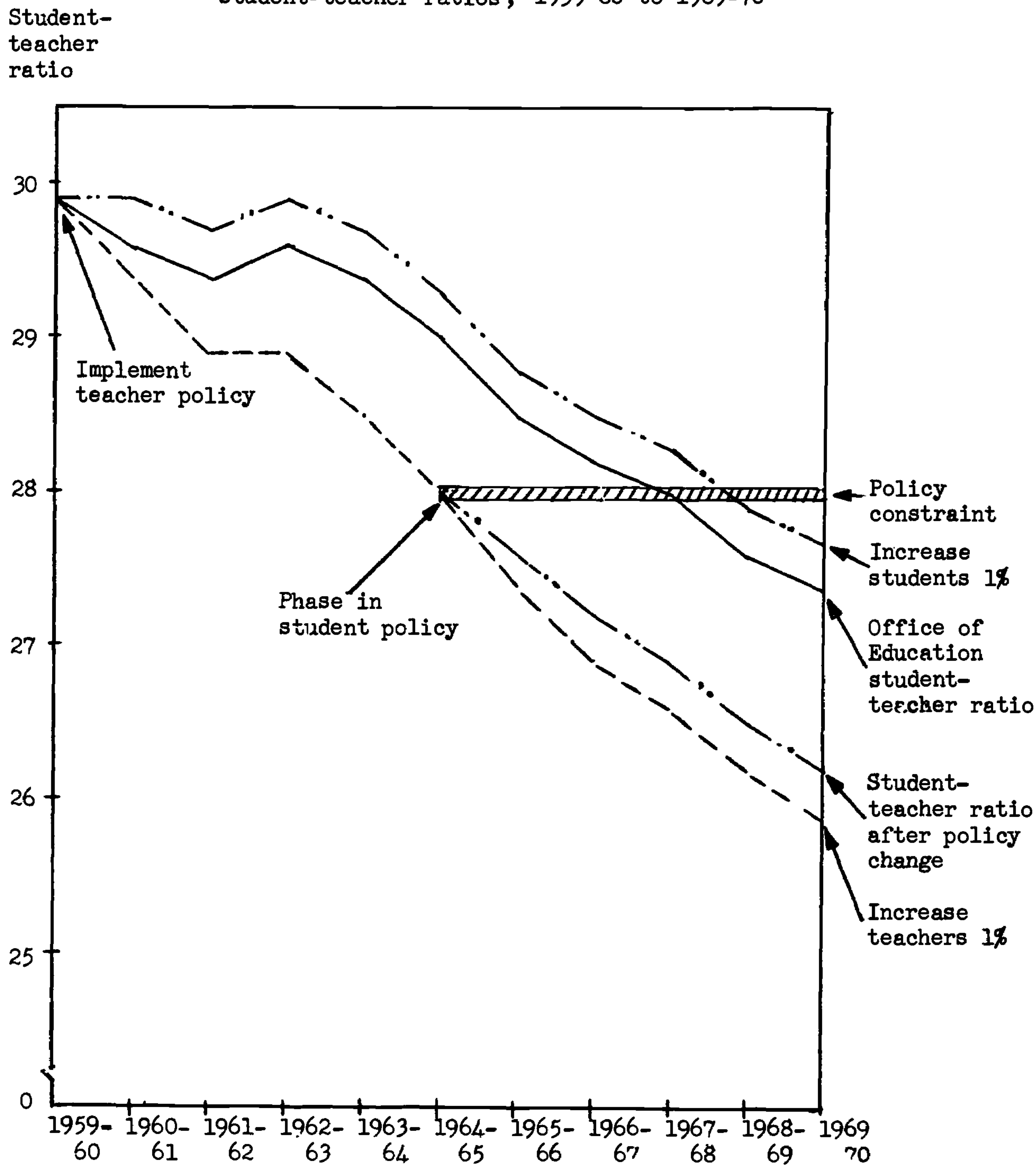
Suppose it had been decided just prior to September of 1959 to implement policies to attain a national student-teacher ratio of 28.0 by September of 1964, and to never exceed that value once it was attained. As a side condition, also assume that the student-teacher ratio policy was to be effected with a minimum impact (say one percent) on the retention rates of students and/or teachers. Assume further that it was required to implement antidropout policies before the end of the 10-year interval, 1959-60 to 1969-70.

That these multiple objectives could have been met by policy sequencing is shown in figure 17. Under ordinary conditions, the OE student-teacher ratio, although declining over the interval, would not have reached 28.0 until the 1967-68 academic year, or three years late. A student retention policy under those circumstances could not have been introduced until the final two years of the interval even if the constraint of 28.0 were moved ahead three years.

However, if the first policy implemented were one of increasing the teacher retention rates by one percent, the student-teacher ratio would have fallen swiftly enough to meet the 28.0 objective by the 1964-65 academic year, and the sequence policy of increasing the retention rate (i.e., decreasing the dropout rate) could have been embarked upon at that time.

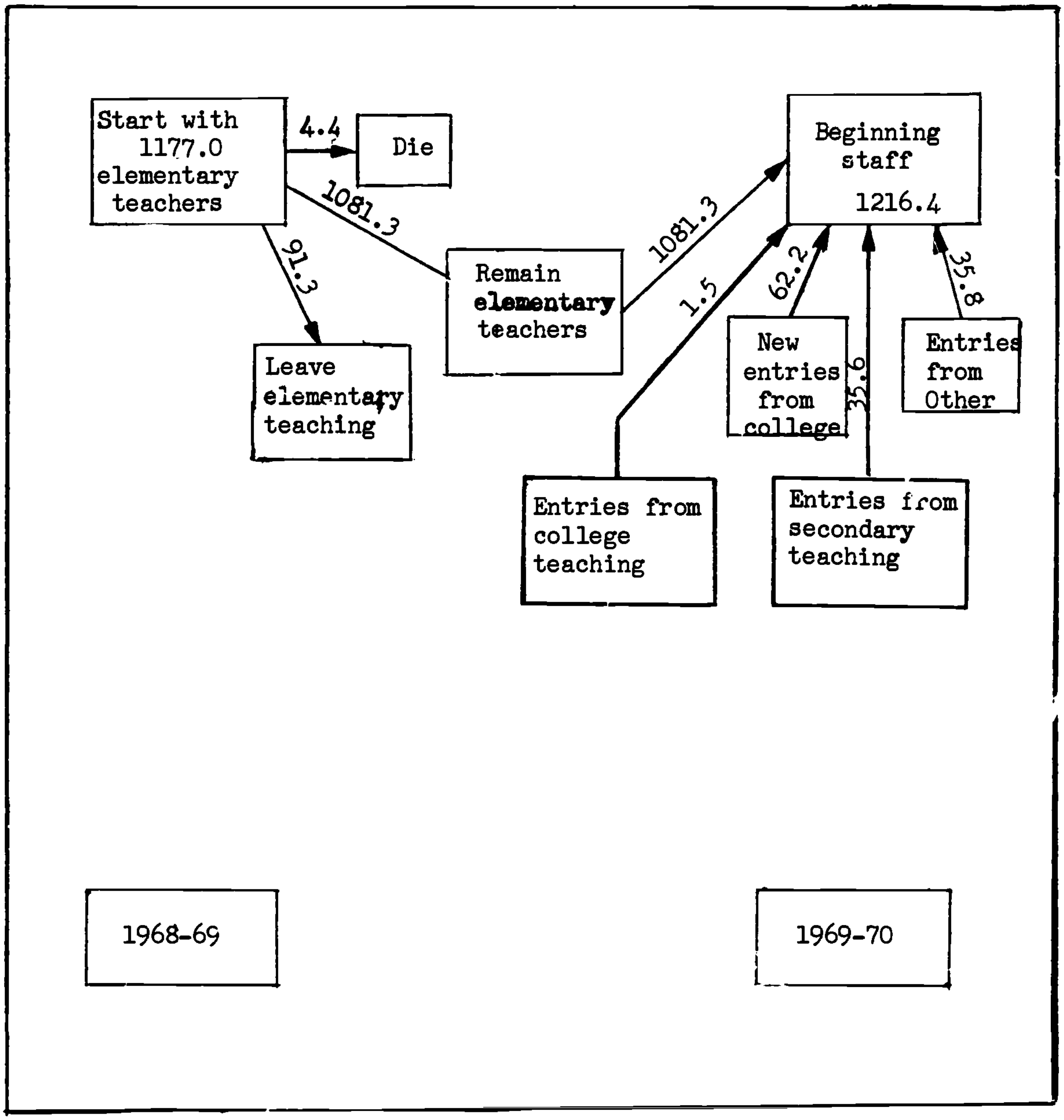
Structural studies.- Another use of DYNAMOD II which is worthy of note is in describing the structure of the flows in the educational system. In building the model, it was necessary to specify and estimate the significant cross-flows of the various subpopulations. For example, figure 18 portrays the expected flows into and out of the elementary school teaching sector from 1968-69 to 1969-70. Of the 91 thousand expected to leave elementary school teaching, some undoubtedly will drift to the secondary school and college teaching sectors. (A lack of data prevented the quantification of these flows.)

Figure 17.-Hypothetical illustration of the use of DYNAMOD II for policy sequencing applied to elementary school student-teacher ratios, 1959-60 to 1969-70



Source: Appendix tables C-1 and D-1

Figure 18.-DYNAMOD II estimates of the flows of elementary school teachers, 1968-69 to 1969-70
(Thousands)



Source: Derived from DYNAMOD II parameter data

The 62.2 thousand new entries from college will provide the largest source of replacement and growth for the elementary school teaching sector. Nearly 36 thousand will come in from the secondary school teaching sector and about the same amount will come in from outside the educational system.

In secondary school teaching, the losses of over 35 thousand to the elementary school teaching sector will be offset by entries from outside the school (figure 19). However, the 58 thousand secondary school teachers that will leave the teaching field will be more than replaced by new entries from the college student sector. In terms of any experience on the average, less than 3 thousand entries will come from the college teaching sector.

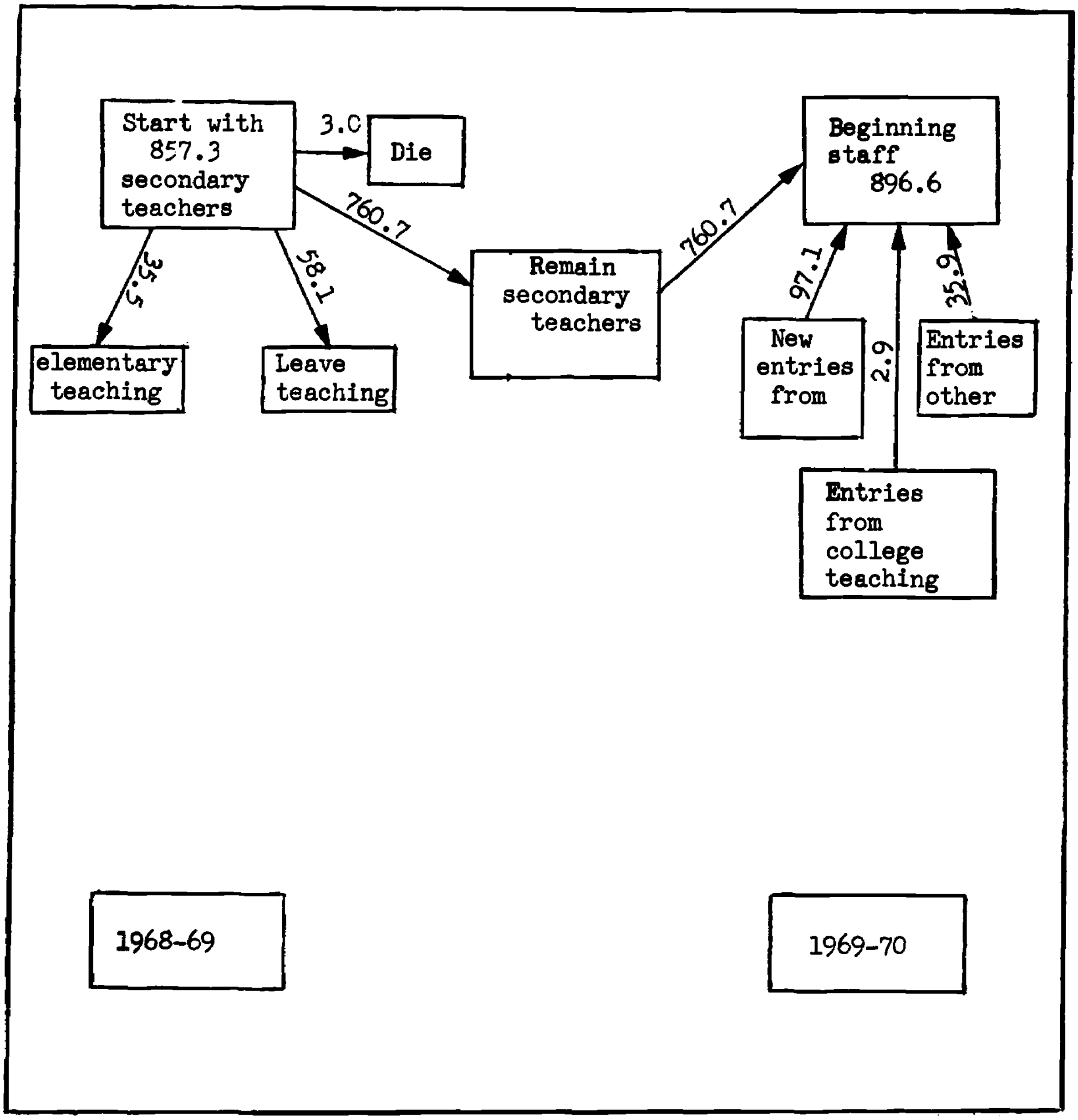
Figure 20 depicts the estimates of the flows of college teachers from the beginning of 1968-69 to 1969-70. It is expected that 22 thousand of these college teachers will leave the teaching field, 2 thousand will die, and 4 thousand will switch teaching fields. This loss will not be entirely offset by new entries from the college student sector, but rather colleges will have to depend on people entering from outside the system to close the attrition gap and provide for the expected net growth. Some of the extrasystem entrants, about 4 thousand, will be returning to college teaching from leaves of absence, but the other 29 thousand are observed to be very important persons in terms of meeting the objectives of faculty growth in higher education. If, for any reason the interest of these people falls and they slow down their rate of entry, policymakers will be faced with the dilemma of somehow either raising the rate of entrance from the student sector, or making college teaching as attractive to those outside the system as it had been.

To test the sensitivity of the three levels of teaching to transfers from outside the system, three computer runs were executed wherein for a given level of teaching, the teacher retention rate was set to the survival rate (i.e., 1.0000 minus the death rate), no transfers out of teaching were permitted except deaths, and the only inflows to teaching were from the college student sector.

The results of this test are shown in figure 21. Illustrative of the discussion above it is noted that, while the population of college teachers would have continued to increase over the interval, its rate of growth would have been substantially lower than that produced by the original calculations.

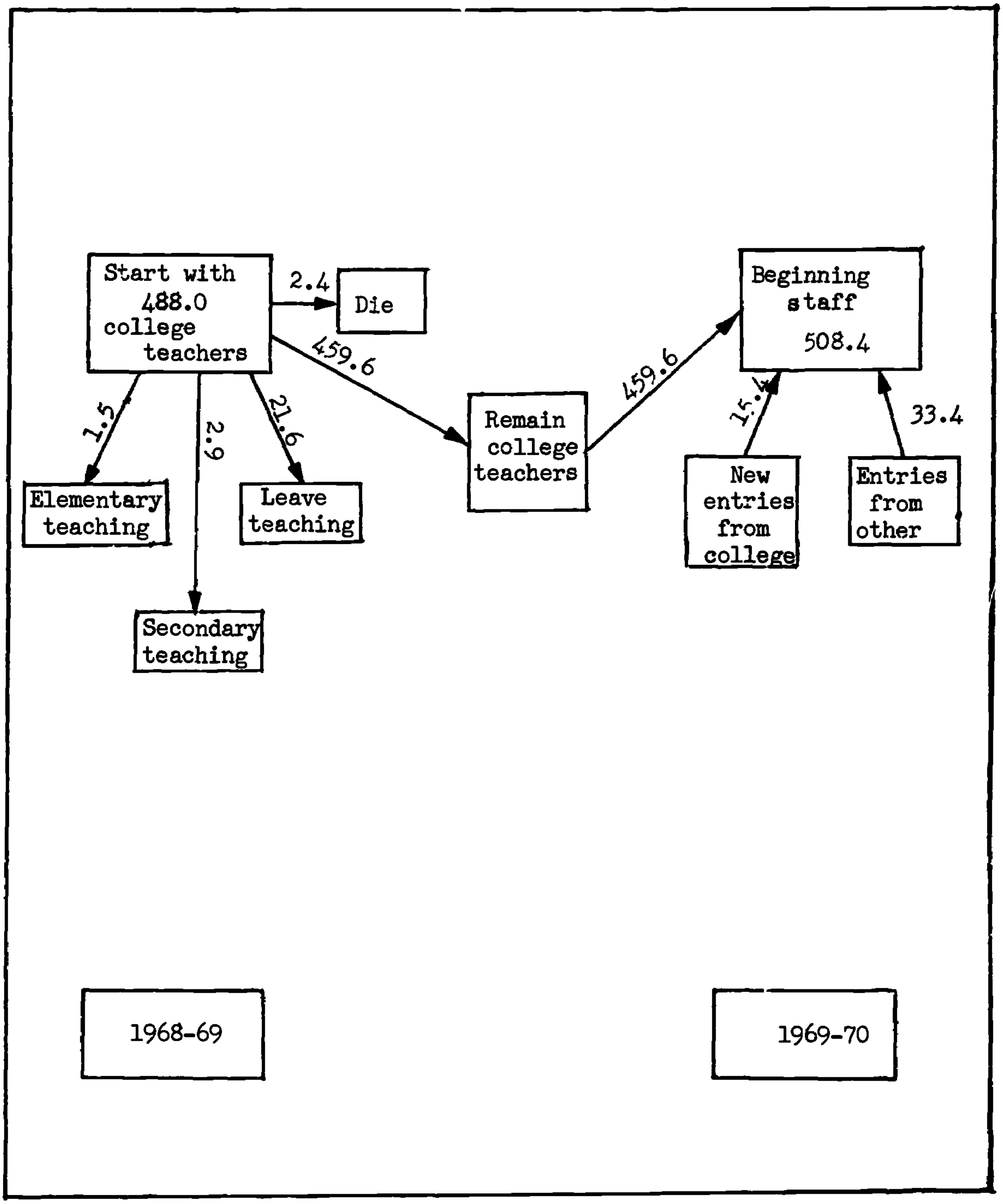
On the other hand, it is clear that the two other teaching levels are less dependent on entries from outside the system than is the college sector. That is, the elementary and secondary school teaching sectors, in an emergency, could meet most of their replacement and net growth needs through effective policies centered on retention rather than on replacement.

Figure 19.-DYNAMOD II estimates of the flows of secondary school teachers, 1968-69 to 1969-70
(Thousands)



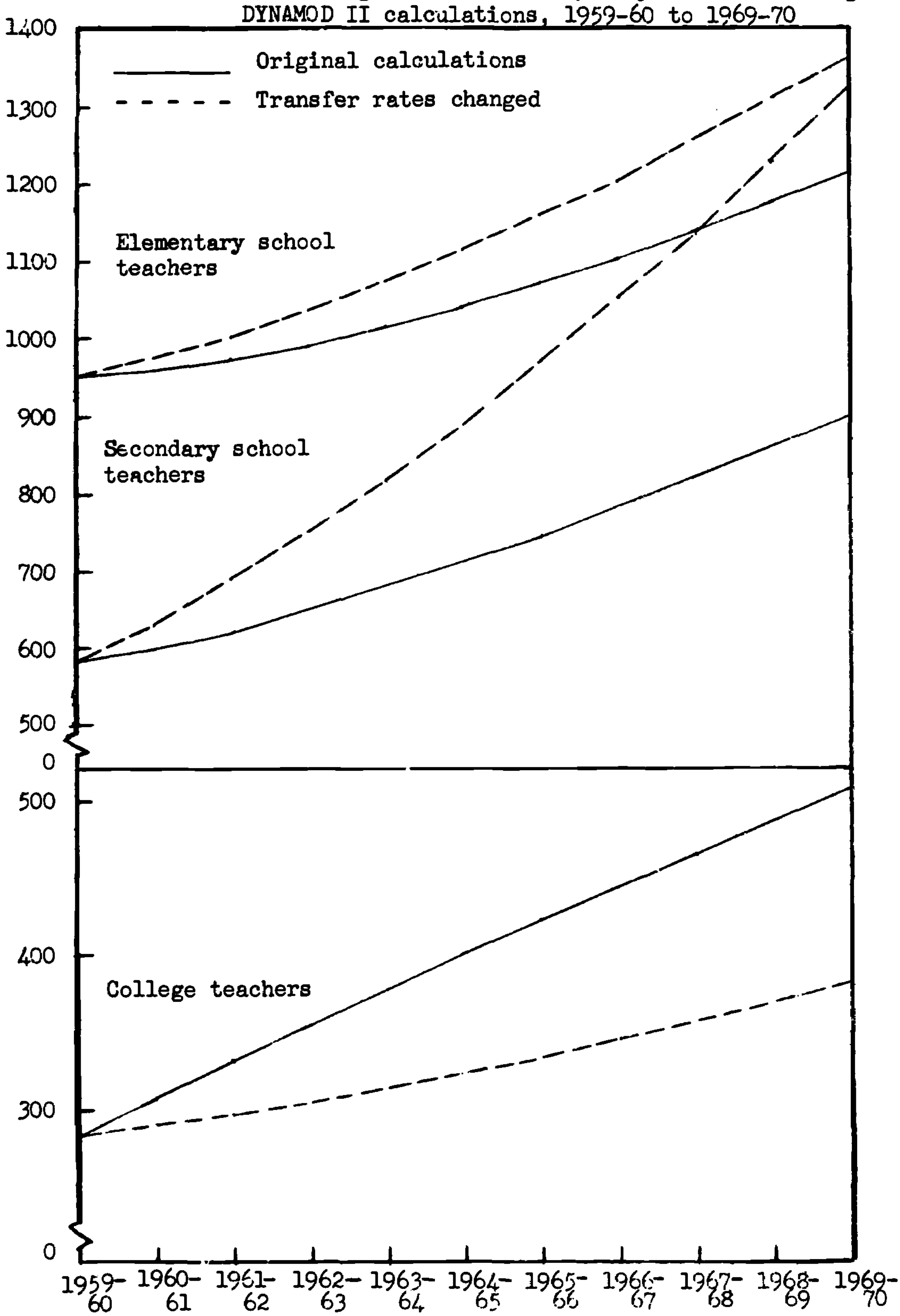
Source: Derived from DYNAMOD II parameter data

Figure 20. -DYNAMOD II estimates of the flows of college teachers, 1968-69 to 1969-70 (Thousands)



Source: Derived from DYNAMOD II parameter data

Figure 21.-Hypothesized effects of setting teacher retention rates equal to survival rates and eliminating all sources of entry to teaching except through the college student sector, compared to the original DYNAMOD II calculations, 1959-60 to 1969-70



Source: Appendix table D-2

Limitations of the Data

The data are subject to all the limitations published elsewhere by the Office of Education and, where applicable, the Bureau of the Census. The basic data inputs are derived primarily from the Bureau of the Census' 1/1,000 samples data tape, and hence are subject to sampling errors which become relatively larger as the population is subdivided in more detail. Efforts were made to adjust known differences, but these efforts cannot be considered to be completely effective.

For this report, the greatest effort was expended on calibrating to the major educational population categories (elementary school students, secondary school students, and so on). Therefore, only secondary emphasis was placed on the sex, race and age distributions within the entire population.

APPENDIX A

Summary calculations of DYNAMOD II

LIST OF APPENDIX A ILLUSTRATIONS

APPENDIX A

Summary calculations of DYNAMOD II

The data presented in this appendix are summary groupings of the detailed calculations shown in text tables 2 through 5. Specific educational levels, such as all elementary school students or all secondary school teachers are the items of interest. In addition, selected demographic distributions such as age, sex, and race are presented. The final portion of the section is devoted to a brief discussion of dropouts.

Depending upon whether educational or other demographic characteristics of the population are being presented, either "Series E" or "Series P" projections are also presented to indicate their degree of association with the DYNAMOD II calculations.

Series E projections are the official educational projections of the Office of Education. Series P is a label of convenience given to the selected official demographic projections of the Bureau of the Census used in this report.1/

Educational System Characteristics

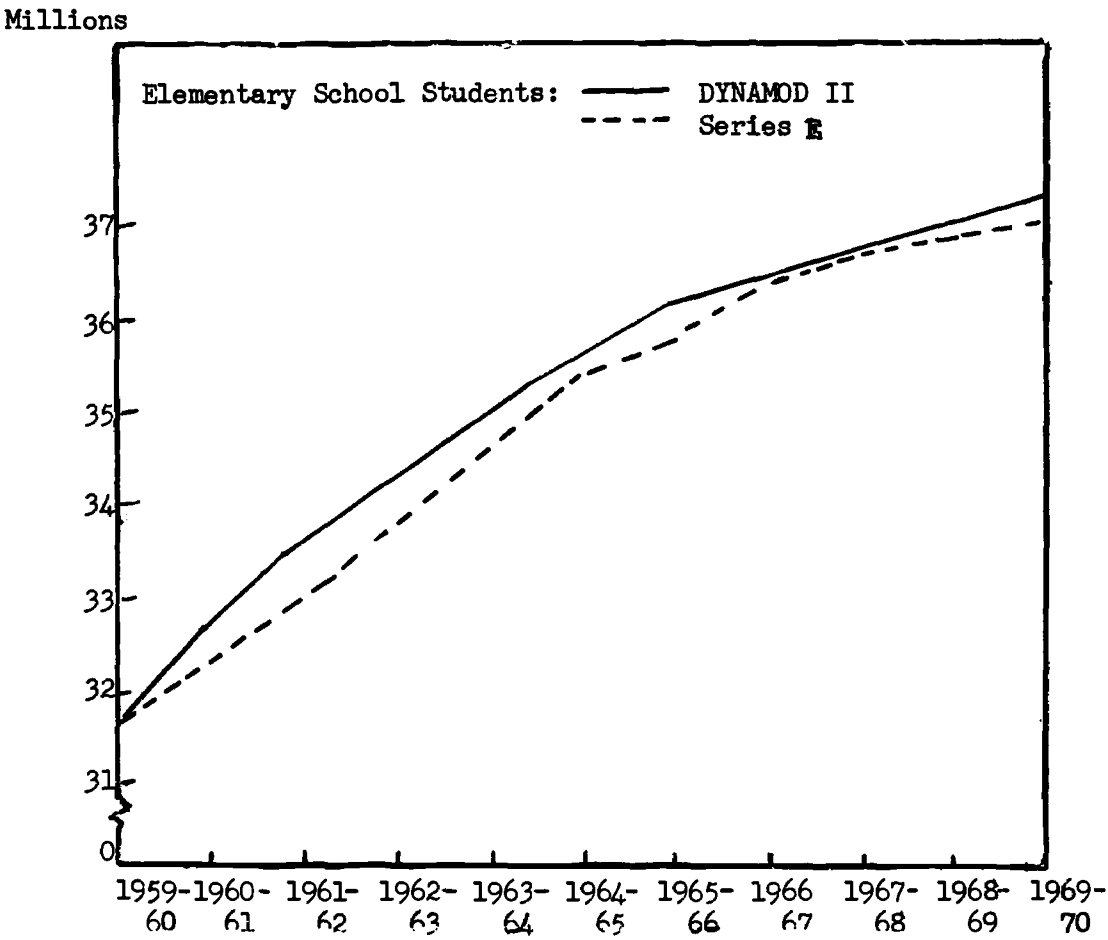
Students, 1959-60 to 1969-70. The DYNAMOD II calculations of elementary school students are slightly higher than the Series E projections throughout the interval (figure A-1). The largest difference is 1.9 percent, occurring in 1961-62, and by 1969-70 this figure drops to .1 percent. The percent differences mentioned in this discussion are found in the appendix tables at the end of this section.

DYNAMOD II calculations of secondary school students are illustrated with Series E projections in figure A-2. The DYNAMOD II calculations are slightly lower than the Series E data in the later years, becoming 5.2 percent lower by 1969-70.

Because DYNAMOD II uses grouped age categories rather than single years of age, any increase in the number of students (or teachers) caused by the sudden appearance of a disproportionately large number of people of a particular age tends to be smoothed out over time. An example of this is seen in figure A-2. The line representing Series E projections of secondary students "peaks" in 1964-65, while the DYNAMOD II line indicates a more steady increase over the years of calculation.

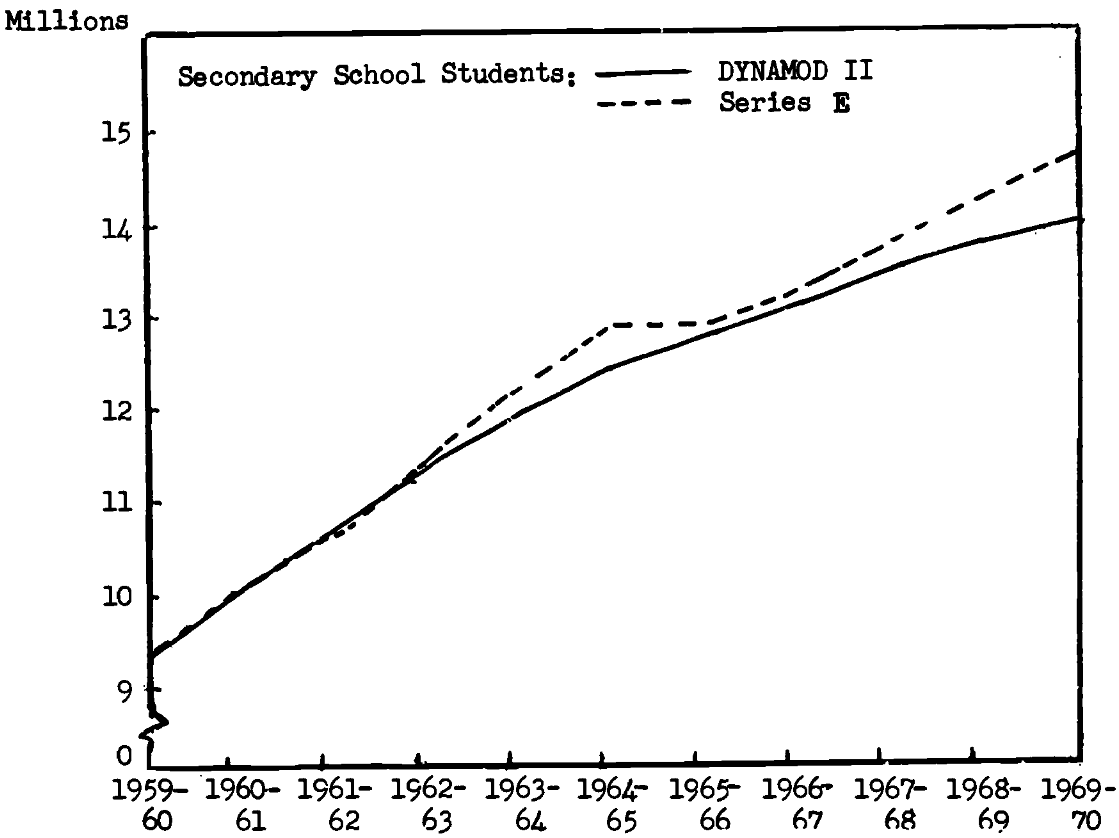
1/ The Series E projections used for the calibrations were published in U.S. Department of Health, Education, and Welfare, Office of Education, Projections of Educational Statistics to 1974-75, 1965 Edition, OE-10030-65 (Washington,D.C.: Supt. of Documents, U.S. Government Printing Office). The primary reference document for calibrating DYNAMOD II projections to those of Series P is U.S. Department of Commerce, Bureau of the Census, Population Estimates, Series P-25, No. 359, February 20, 1967, and backup data supplied by the Bureau of the Census.

Figure A-1. -DYNAMOD II calculations and Series E projections of elementary school students, 1959-60 to 1969-70



Source: Appendix table A-1

Figure A-2.-DYNAMOD II calculations and Series E projections of secondary school students, 1959-60 to 1969-70



Source: Appendix table A-1

Figure A-3 shows DYNAMOD II calculations of college students to increase almost linearly over the calculational interval.2/ In the main, however, the levels of the two time series remain close enough to keep the responses to postulated policy changes approximately correct.

Teachers, 1959-60 to 1969-70. DYNAMOD II calculations of elementary school teachers are lower than those of Series E for each of the calculation years excepting the last two (figure A-4). In the final year, the DYNAMOD II estimate is 3.1 percent higher than that of Series E. The greatest difference is in 1964-65, when the DYNAMOD II estimate is 4.5 percent below that of Series E.

Figure A-5 shows DYNAMOD II calculations of secondary school teachers to be somewhat less than those of Series E for each of the calculation years. The percent difference increases each year to 1964-65, where the DYNAMOD II figure is 9.9 percent lower than that of Series E. The difference then decreases for the remaining years, becoming 2.3 percent in 1969-70.

DYNAMOD II calculations of college teachers are higher than those of Series R through 1964-65 (figure A-6). For the remaining years, DYNAMOD II figures are less than the Series E data, with a difference of 3.1 percent in the final academic year, 1969-70.

Other Demographic Characteristics

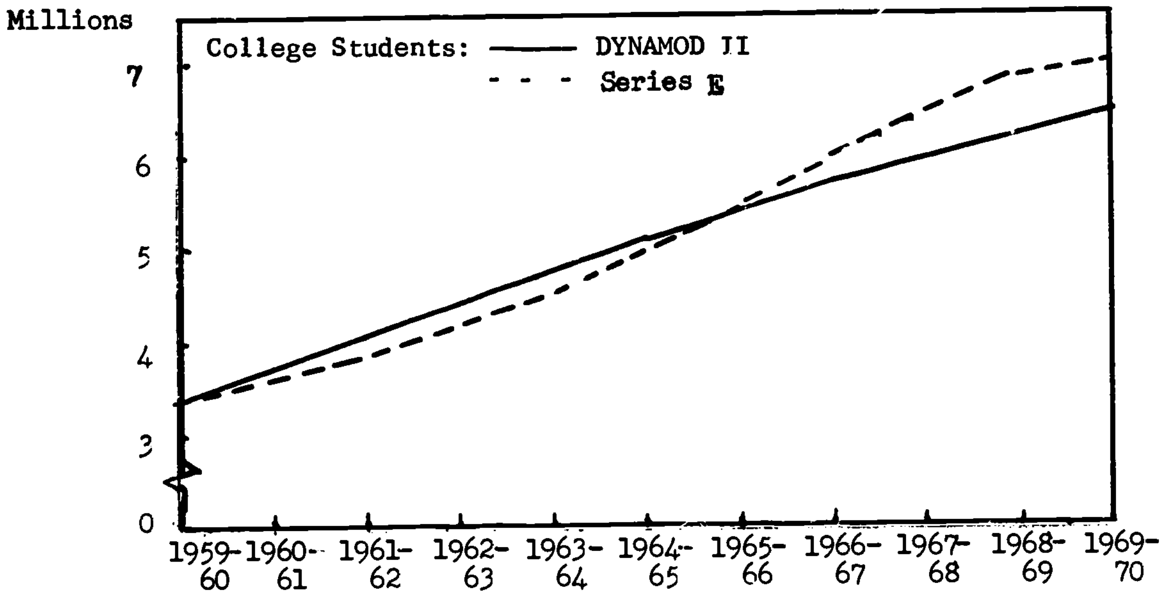
The results of DYNAMOD II's calculations of age, sex and race are presented below along with the respective projections from Series P. The calibrations of the DYNAMOD II demographic data to Series P were based on figures obtained from Current Population Reports, Series P-25, No. 359, February, 1967. However, the births, which affect primarily the 0-4 age group, were taken from Series P-25, No. 345, July 1966. The overall effects of these differences were minor.

It should be noted that DYNAMOD II calculations should run slightly below those of Series P, because the demographic variables in DYNAMOD II are centered on April 1, while the Series P figures are centered on July 1.

Age. The comparison of the calculations of the age composition of the population in DYNAMOD II with the Series P projections is illustrated in figure A-7. With the exception of the 15-19 year old group for 1966, the relative differences between the DYNAMOD II

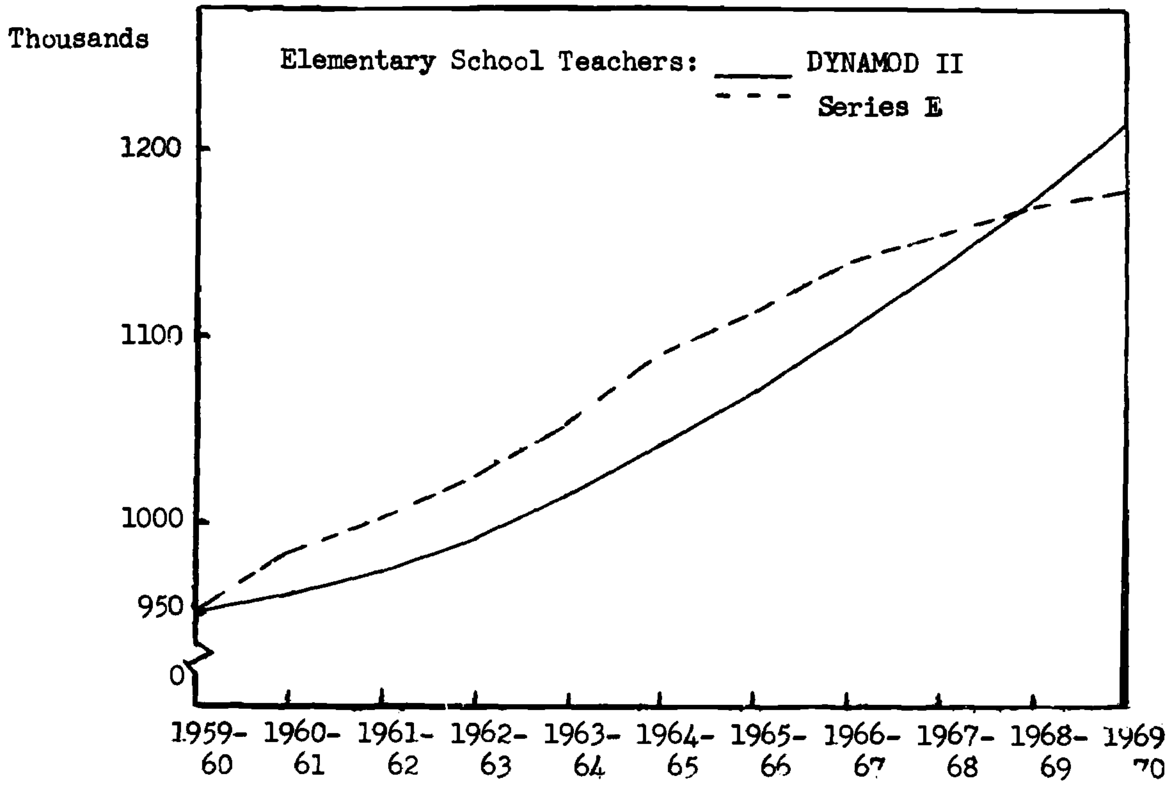
2/ Actually, there is a slight deceleration over the interval, as was the case with Series E in the last four years of the interval.

Figure A-3.-DYNAMOD II calculations and Series E projections of college students, 1959-60 to 1969-70



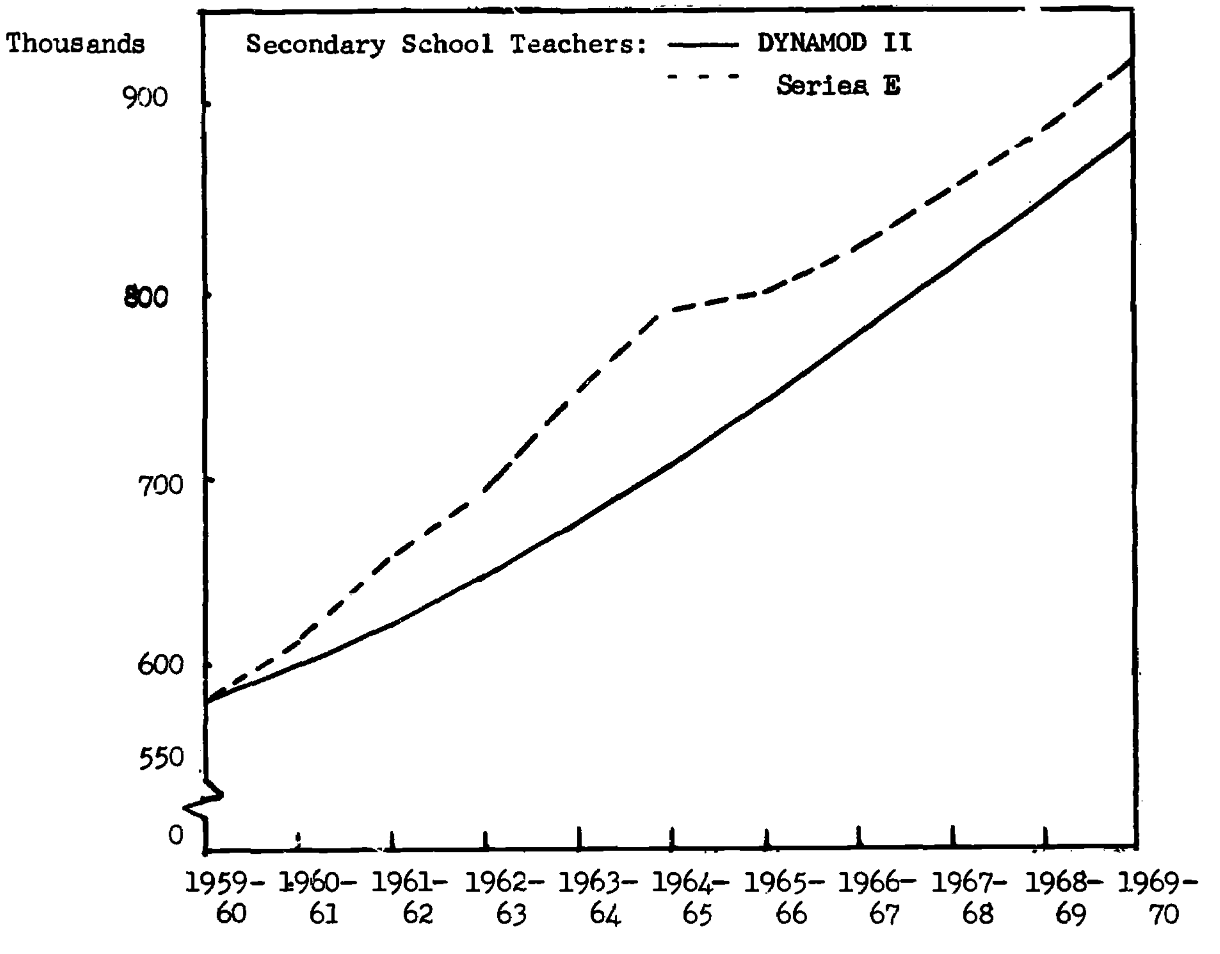
Source: Appendix table A-1

Figure A-4.-DYNAMOD II calculations and Series E projections of elementary school teachers, 1959-60 to 1969-70



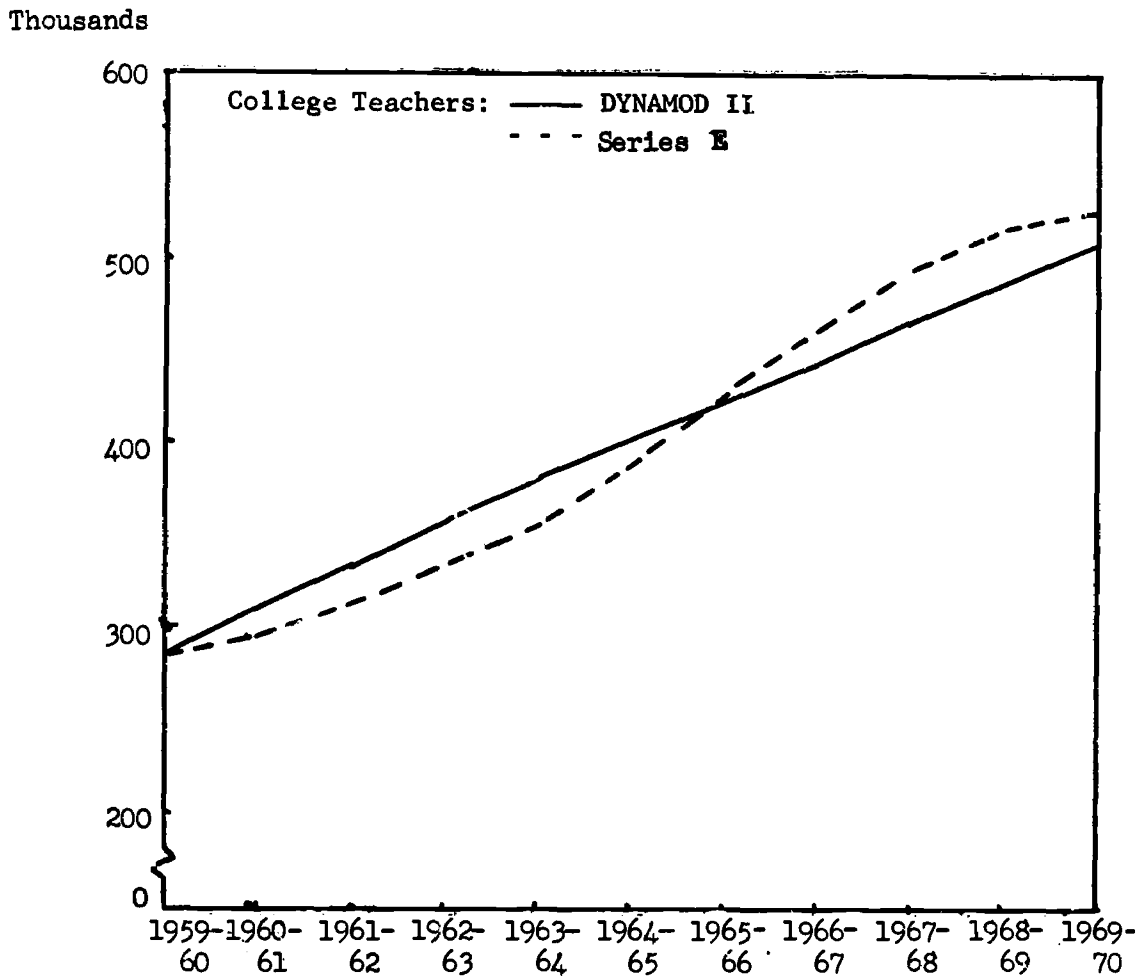
Source: Appendix table A-3

Figure A-5.-DYNAMOD II calculations and Series E projections of secondary school teachers, 1959-60 to 1969-70



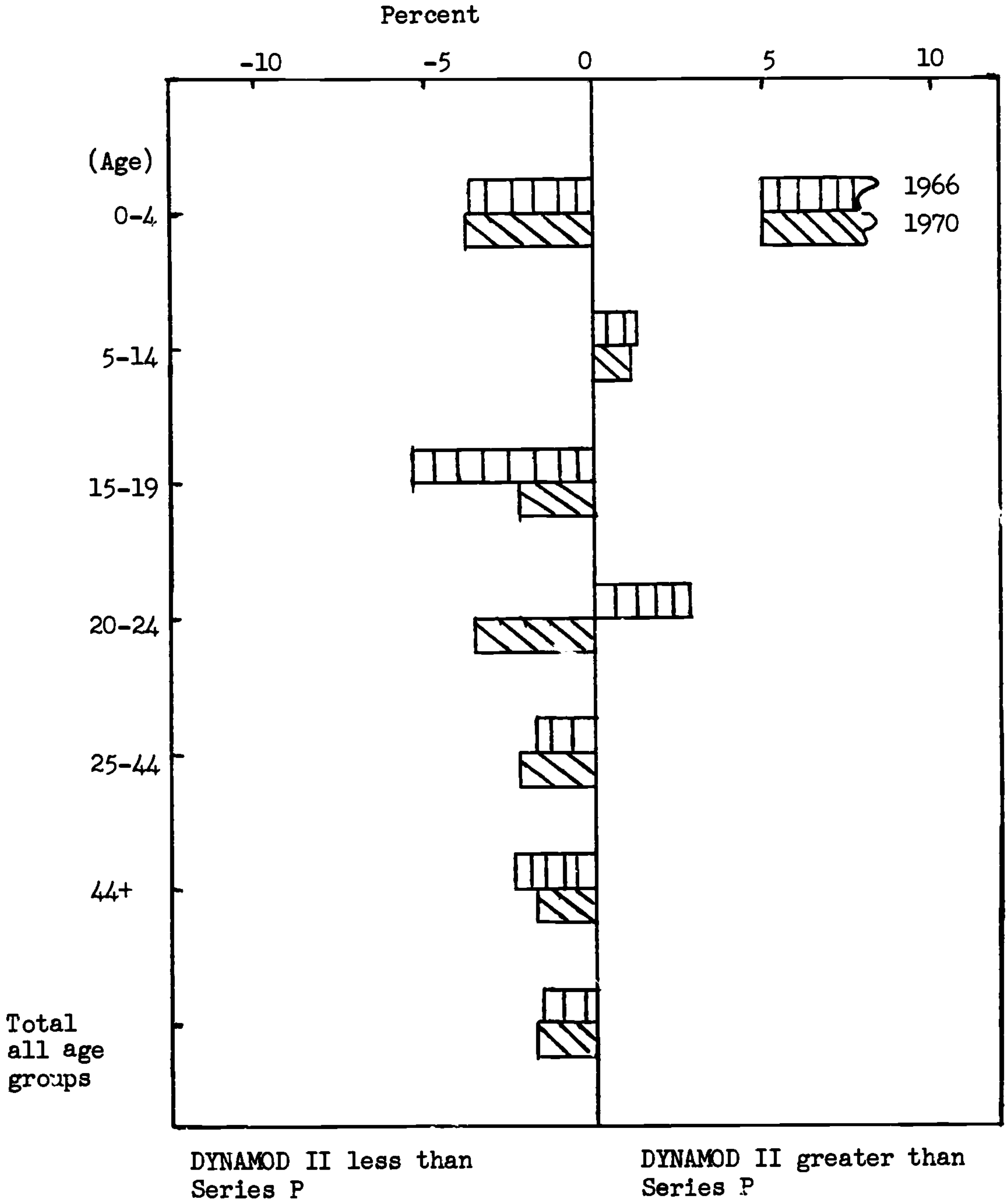
Source: Appendix table A-3

Figure A-6.-DYNAMOD II calculations and Series E projections of college teachers, 1959-60 to 1969-70



Source: Appendix table A-3

Figure A-7. - DYNAMOD II calculations and Series P projections by age, 1966 and 1970



Source: Appendix table A-4

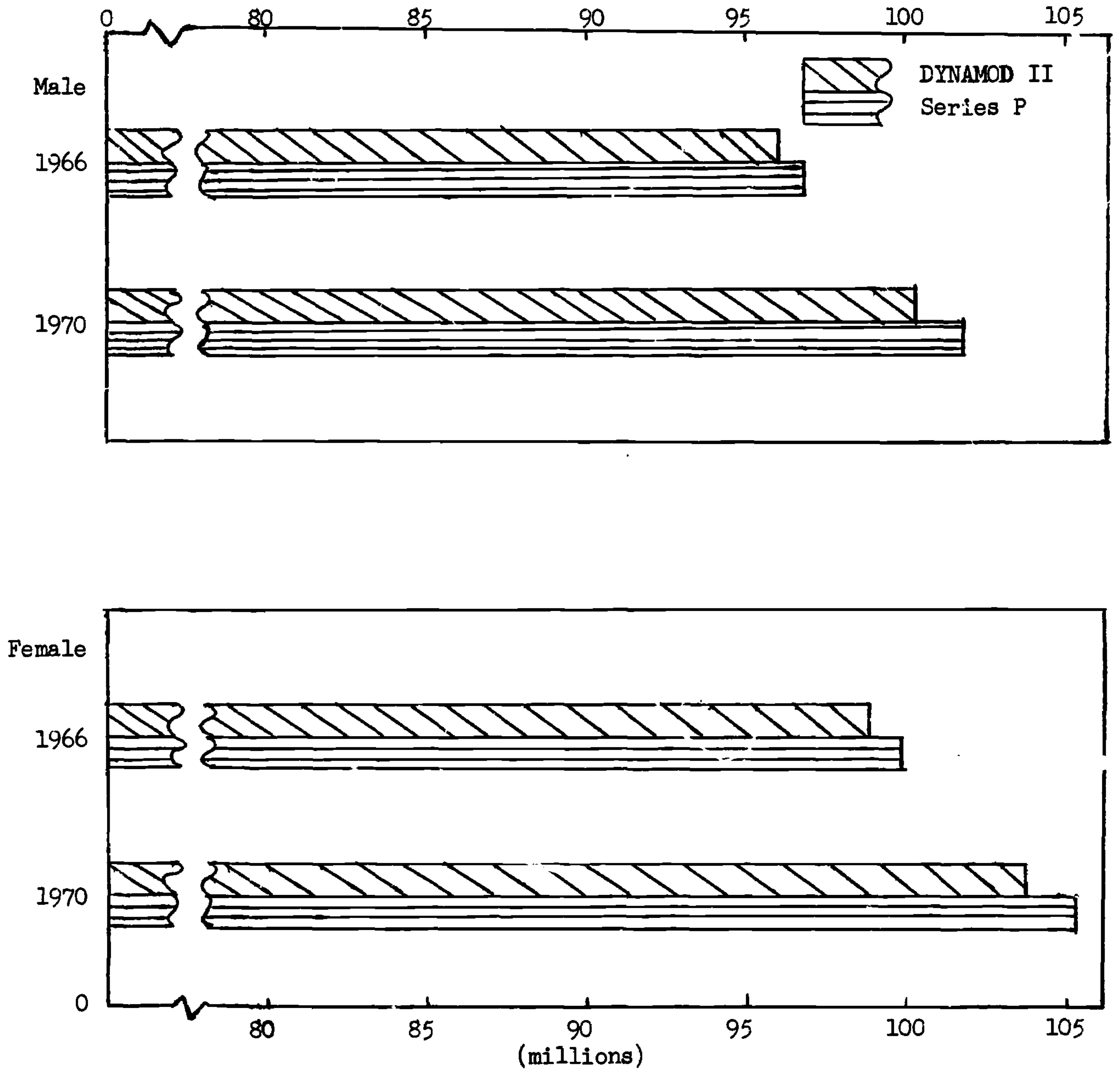
calculations and those in Series P all were less than 4 percent.

The relative deviations tend to be largest in the younger age groups. In addition, with the exception of the 5-14 year old group, DYNAMOD II calculations tend to be slightly lower than Series P.

Sex. Figure A-8 shows DYNAMOD II calculations by sex for the years 160, 1966, and 1970. For males, the DYNAMOD II 1970 calculations is 1.5 percent less than the Series P projection, while for females the difference is 1.6 percent.

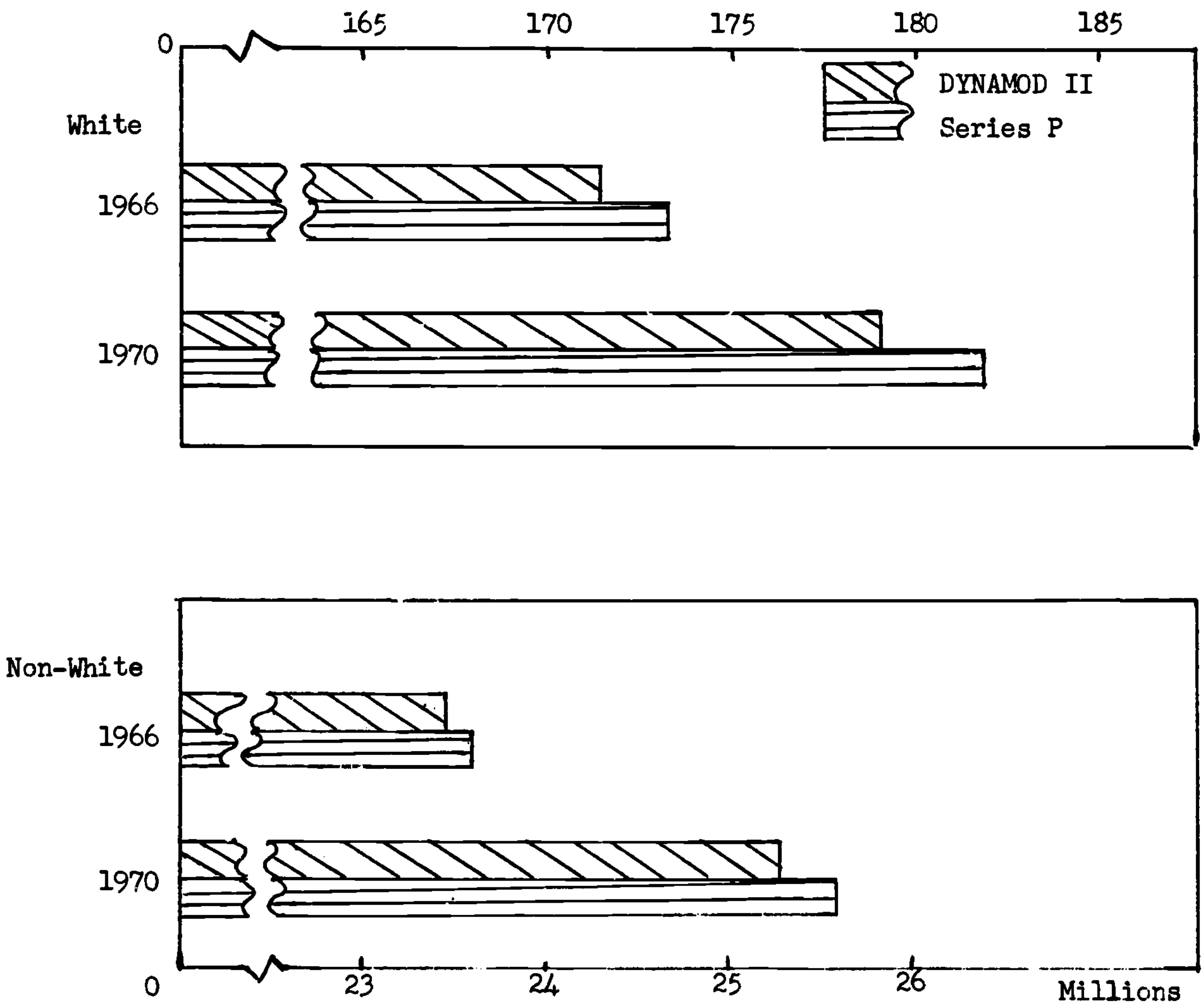
Race. A graphic comparison of DYNAMOD II calculations and Series P projections by race is shown in figure A-9. For whites, the DYNAMOD II calculation is 1.0 percent below Series P in 1966, becoming 1.6 percent below in 1970. For nonwhites, DYNAMOD II is only .8 percent lower than Series P in 1966, drifting to -1.2 percent by 1970.

Figure A-8.-DYNAMOD II calculations and Series P projections, by sex, 1966 and 1970



Source: Appendix table A-5

Figure A-9.-DYNAMOD II calculations and Series P projections, by race, 1966 and 1970



Source: Appendix table A-6

Appendix Table A-1.-DYNAMOD II calculations and Series E projections of students, 1959-60 to 1969-70
(Thousands)

		1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
Elementary School Students	DYNAMOD II	31,511	32,675	33,489	34,252	34,935	35,525	36,009	36,371	36,635	36,848	37,048
	Series E	31,511	32,198	32,869	33,737	34,504	35,325	35,700	36,300	36,600	36,800	37,000
	Percent difference	---	1.5	1.9	1.5	1.2	.6	.9	.2	.1	.1	.1
Secondary School Students	DYNAMOD II	9,271	10,012	10,707	11,309	11,836	12,301	12,709	13,064	13,368	13,622	13,835
	Series E	9,271	9,983	10,595	11,312	12,183	12,791	12,800	13,100	13,600	14,100	14,600
	Percent difference	---	.3	1.1	---	-2.8	-3.8	-.7	-.3	-1.7	-3.4	-5.2
College Students	DYNAMOD II	3,377	3,762	4,111	4,461	4,807	5,143	5,465	5,769	6,054	6,318	6,559
	Series E	3,377	3,583	3,861	4,175	4,495	4,950	5,435	5,924	6,410	6,820	6,966
	Percent difference	---	5.0	6.5	6.9	6.9	3.9	.6	-2.6	-5.6	-7.4	-5.8

Table A-2.-DYNAMOD II calculations of elementary and secondary school dropouts by sex-race group, 1959-60 to 1968-69[1/]
(Thousands)

	1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69
Elementary school:										
White male	88	90	92	94	96	98	99	101	102	103
White female	75	83	90	95	99	102	105	107	108	109
Nonwhite male	32	30	29	28	27	27	27	28	28	28
Nonwhite female	44	46	47	48	49	50	52	53	54	54
Total, elementary school	239	249	258	265	271	277	283	289	292	294
Secondary school:										
White male	391	421	458	490	519	544	565	583	599	612
White female	448	459	478	496	512	527	540	551	560	568
Nonwhite male	46	56	65	73	80	86	91	94	99	102
Nonwhite female	73	80	87	94	100	105	109	114	117	121
Total, secondary school	958	1,016	1,088	1,153	1,211	1,262	1,305	1,342	1,375	1,403
Total elementary and secondary school	1,197	1,265	1,346	1,418	1,482	1,539	1,588	1,631	1,667	1,697

1/ Figures shown for a given year (e.g. 1961-62) are shown one year ahead (e.g. 1962-63) in text tables 2 through 5.

Appendix Table A-3.-DYNAMOD II calculations and Series E projections of secondary school teachers, 1959-60 to 1969-70
(Thousands)

		1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
Elementary school teachers	DYNAMOD II	952	959	973	991	1,015	1,041	1,071	1,104	1,140	1,177	1,216
	Series E	952	984	1,002	1,026	1,053	1,092	1,114	1,141	1,155	1,170	1,179
	Percent difference	---	-2.5	-2.9	-3.4	-3.6	-4.7	-3.9	-3.2	-1.3	.6	3.1
Secondary school teachers	DYNAMOD II	580	599	622	649	678	711	745	781	819	857	897
	Series E	580	610	655	690	743	789	796	820	853	884	918
	Percent difference	---	-1.8	-5.0	-5.9	-8.7	-9.9	-6.4	-4.8	-4.0	-3.1	-2.3
College teachers	DYNAMOD II	283	308	332	355	378	401	423	445	466	487	508
	Series E	283	296	313	336	358	389	425	459	493	517	524
	Percent difference	---	4.1	6.1	5.7	5.6	3.1	-.5	-3.1	-5.5	5.8	-3.1

Appendix Table A-4.-DYNAMOD II calculations and Series P projections of age, 1960-1970
(Thousands)

AGE		1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
0 - 4	DYNAMOD II	20,365	20,354	20,247	20,087	19,917	19,589	19,139	18,905	18,879	19,019	19,293
	Series P	20,364	---	---	---	---	---	19,851	---	---	---	20,027
	Percent difference	---	---	---	---	---	---	-3.6	---	---	---	-3.7
5 -14	DYNAMOD II	35,735	37,073	38,062	38,902	39,626	40,243	40,731	41,075	41,328	41,543	41,761
	Series P	35,735	---	---	---	---	---	40,208	---	---	---	41,261
	Percent difference	---	---	---	---	---	---	1.3	---	---	---	1.2
15-19	DYNAMOD II	13,467	13,656	14,271	14,978	15,678	16,336	16,939	17,478	17,951	18,359	18,705
	Series P	13,467	---	---	---	---	---	17,895	---	---	---	19,100
	Percent difference	---	---	---	---	---	---	-5.3	---	---	---	-2.1
20-24	DYNAMOD II	11,116	11,871	12,423	12,910	13,399	13,911	14,447	14,999	15,558	16,111	16,650
	Series P	11,116	---	---	---	---	---	14,047	---	---	---	17,261
	Percent difference	---	---	---	---	---	---	2.8	---	---	---	-3.5
25-44	DYNAMOD II	47,134	46,628	46,285	46,061	45,940	45,917	45,992	46,162	46,426	46,778	47,213
	Series P	47,134	---	---	---	---	---	46,792	---	---	---	48,276
	Percent difference	---	---	---	---	---	---	-1.7	---	---	---	-2.2
44 +	DYNAMOD II	52,865	53,766	54,616	55,423	56,195	56,937	56,657	58,358	59,047	59,729	60,407
	Series P	52,866	---	---	---	---	---	58,049	---	---	---	61,402
	Percent difference	---	---	---	---	---	---	-2.4	---	---	---	-1.6

Appendix table A-4 cont'd.

Appendix table A-4 (Cont'd.)

		1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Total	DYNAMOD II	180,682	183,348	185,904	188,361	190,755	192,933	193,905	196,977	199,189	201,539	204,029
	Series P[1/]	180,684	---	---	---	---	---	196,842	---	---	---	207,326
	Percent difference	---	---	---	---	---	---	-1.5	---	---	---	-1.6

Note DYNAMOD II figures as of April 1; Series P as of July 1.

1/ Columns may not add to total due to rounding.

Appendix Table A-5.-DYNAMOD II calculations and Series P projections of sex, 1960-1970
(Thousands)

		1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Male	DYNAMOD II	89,331	90,592	91,795	92,951	94,076	95,093	96,005	96,972	98,011	99,122	100,306
	Series P	89,332	---	---	---	---	---	96,900	---	---	---	101,882
	Percent difference	---	---	---	---	---	---	-0.9	---	---	---	-1.5
Female	DYNAMOD II	91,351	92,758	94,109	95,410	96,678	97,840	98,899	100,006	101,178	102,417	103,722
	Series P	91,352	---	---	---	---	---	99,942	---	---	---	105,444
	Percent difference	---	---	---	---	---	---	-1.0	---	---	---	-1.6

Appendix Table A-6.-DYNAMOD II calculations and Series P projections of race, 1960-1970
(Thousands)

		1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
White	DYNAMOD II	160,030	162,212	164,288	166,273	168,191	169,927	171,493	173,143	174,906	176,783	178,774
	Series P	160,033	---	---	---	---	---	173,253	---	---	---	181,753
	Percent difference	---	---	---	----	---	---	-1.0	---	---	---	-1.6
Non-White	DYNAMOD II	20,652	21,138	21,616	22,088	22,563	23,006	23,411	23,835	24,283	24,756	25,254
	Series P	20,651	---	---	---	---	---	23,589	---	---	---	25,573
	Percent difference	---	---	---	---	---	---	-0.8	---	---	---	-1.2

APPENDIX B

Tables of the Effects of Using Different Birth Estimates

LIST OF APPENDIX B TABLES

Appendix Table B-1.-Series D and Series B birth data used in DYNAMOD II, 1959-60 to 1969-60 (Thousands)

Year 1/	Series D 2/	Series B 3/	Difference (Series B minus Series D)
1959-60		4279	
1960-61		4350	
1961-62		4260	
1962-63		4186	
1963-64		4142	
1964-65		3948	
1965-66	3678	3758	80
1966-67	3590	3880	290
1967-68	3670	4034	364
1968-69	3740	4191	451
1969-70	3830	4353	523

1/ Births are centered on fiscal year beginning July 1. The births used in DYNAMOD II from 1959-60 to 1964-65 were published in Births and Death Rate Projections Used in Present Student-Teachers Population Flow Models, T. Okada, Technical Note Number 11, December 1966.

2/ Ibid.

3/ U.S. Bureau of the Census, Current Population Reports, Population Estimates, Series P-25, No. 345, Op.cit.

Appendix Table B-2.-Comparison of DYNAMOD II calculations using different birth estimates, by selected age groups, 1966-1970 (Thousands)

AGE		1966	1967	1968	1969	1970
0 - 4	Series B 1/	19,139	18,905	18,879	19,019	19,293
	Series D 2/	19,059	18,551	18,233	18,055	18,008
	Percent difference	-0.4	-1.9	-3.4	-5.1	-6.7
5 -14	Series B	40,731	41,075	41,328	41,543	41,761
	Series D	40,731	41,060	41,244	41,333	41,367
	Percent difference	---	---	-0.2	-0.5	-0.9
15-19	Series B	16,939	17,478	17,951	18,359	18,705
	Series D	16,939	17,478	17,950	18,353	18,689
	Percent difference	---	---	---	---	-0.1

1/ Series B estimates from U.S. Bureau of Census, Current Population Reports, Population Estimates, Series P-25, No. 345, Op. cit.

2/ Series D estimates by T. Okada, Births and Death Rate Projections Used in Present Student-Teacher Population Flow Models, Technical Note Number 11, December 14, 1966.

Appendix Table B-3.-Comparison of DYNAMOD II calculations using different birth estimates, by student population, 1965-66 to 1969-70 (Thousands)

		1965-66	1966-67	1967-68	1968-69	1969-70
Elementary school students	Series B	36,009	36,371	36,635	36,848	37,048
	Series D	36,009	36,362	36,583	36,703	36,762
	Percent difference	---	---	-0.1	-0.4	-0.8
Secondary school students	Series B	12,709	13,064	13,368	13,622	13,835
	Series D	12,709	13,064	13,367	13,617	13,818
	Percent difference	---	---	---	---	-0.1
College students	Series B	5,465	5,769	6,054	6,318	6,559
	Series D	5,465	5,769	6,054	6,318	6,559
	Percent difference	---	---	---	---	---

Appendix Table B-4.-Comparison of DYNAMOD II calculations using different birth estimates, by race, 1966-1970
(Thousands)

		1966	1967	1968	1969	1970
White	Series B	171,493	173,143	174,906	176,783	178,774
	Series D	171,427	172,842	174,315	175,828	177,401
	Percent difference		-0.2	-0.3	-0.5	-0.8
Non-White	Series B	23,411	23,835	24,283	24,756	25,254
	Series D	23,396	23,764	24,142	24,532	24,931
	Percent difference	-0.1	-0.3	-0.6	-0.9	-1.3

Appendix Table B-5.-Comparison of DYNAMOD II calculations using different birth estimates, by sex, 1966-1970
(Thousands)

		1966	1967	1968	1969	1970
Male	Series B	96,005	96,972	98,011	99,122	100,306
	Series D	95,965	96,783	97,637	98,521	99,440
	Percent difference	---	-0.2	-0.4	-0.6	-0.9
Female	Series B	98,899	100,006	101,178	102,417	103,722
	Series D	98,858	99,823	100,820	101,839	102,892
	Percent difference	---	-0.2	-0.4	-0.6	-0.8

Appendix Table B-6.-Death rates used in DYNAMOD II

Age Interval	Category	White Male	White Female	Nonwhite Male	Nonwhite Female
0-4 1/	Elem. sch. students	.0055	.0042	.0107	.0086
	Other	.0055	.0042	.0107	.0086
5-14 1/	Elem. sch. students	.0005	.0003	.0007	.0005
	Second. sch. students	.0005	.0003	.0007	.0005
	Other 3/	.0005	.0003	.0007	.0005
15-19	Elem. sch. students 1/	.0013	.0005	.0016	.0008
	Second. sch. students 1/	.0013	.0005	.0016	.0008
	College students 2/	.0011	.0004	.0014	.0007
	Other 1/,3/	.0013	.0005	.0016	.0008
20-24	Elem. sch. students 1/	.0017	.0006	.0028	.0013
	Second. sch. students 1/	.0017	.0006	.0028	.0013
	College students 2/	.0011	.0004	.0014	.0007
	Elem. sch. teachers 2/	.0011	.0004	.0014	.0007
	Second. sch. teachers 2/	.0011	.0004	.0014	.0007
	Other 1/,3/	.0017	.0006	.0028	.0013
25-44	Elem. sch. students 1/	.0026	.0014	.0061	.0039
	Second. sch. students 1/	.0026	.0014	.0061	.0039
	College students 2/	.0017	.0006	.0028	.0013
	Elem. sch. teachers 2/	.0017	.0006	.0028	.0013
	Second. sch. teachers 2/	.0017	.0006	.0028	.0013
	College teachers 2/	.0017	.0006	.0028	.0013
	Other 1/, 3/	.0026	.0014	.0061	.0039

Table B-6 (Cont'd)

Age Interval	Category	White Male	White Female	Nonwhite Male	Nonwhite Female
45 & over	Elem. sch. teachers 2/	.01	.007	.016	.014
	Second. sch. teachers 2/	.01	.007	.016	.014
	College teachers 2/	.01	.007	.016	.014
	Other 1/	.0318	.0222	.0352	.0262

1/ Death Rates based on actual count of deaths for the population, U.S. Department of Health, Education, and Welfare, Vital Statistics of U.S., Vol. II, Mortality, Part A (Table 1-25), 1964, Washington, D. C.

2/ U.S. Department of Health, Education, and Welfare, "Mortality by Occupation and Industry" Vital Statistics Special Reports, Vol. 53, No. 2, September 1962 (Female rates estimated).

3/ The death rates for the elementary and secondary "dropout" category are identical to those of the "other" category for each respective age group.

APPENDIX C

Tables of the Effects of Variations in the Retention Rates of Students and Teachers

LIST OF APPENDIX C TABLES

Appendix table C-1.-Results of a one-percent increase in the DYNAMOD II retention rates of elementary school students, by level of schooling or teaching affected, 1959-60 to 1969-70
(Thousands)

		1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
Elementary School Students	DYNAMOD II (before change)	31,511	32,674	33,489	34,252	34,935	35,525	36,009	36,371	36,635	36,848	37,048
	DYNAMOD II (after change)	31,511	32,953	33,880	34,677	35,376	35,978	36,471	36,841	37,112	37,329	37,533
	Percent difference	---	.9	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Secondary School Students	DYNAMOD II (before change)	9,271	10,012	10,707	11,309	11,836	12,301	12,709	13,064	13,368	13,622	13,835
	DYNAMOD II (after change)	9,271	10,013	10,737	11,371	11,926	12,412	12,839	13,207	13,522	13,786	14,007
	Percent difference	---	---	.3	.5	.8	.9	1.0	1.1	1.2	1.2	1.2
College Students	DYNAMOD II (before change)	3,377	3,762	4,111	4,461	4,807	5,143	5,465	5,769	6,054	6,318	6,559
	DYNAMOD II (after change)	3,377	3,762	4,112	4,462	4,811	5,152	5,481	5,793	6,085	6,356	6,605
	Percent difference	---	---	---	---	.1	.2	.3	.4	.5	.6	.7
Elementary School Teachers	DYNAMOD II (before change)										1,177	1,216
	DYNAMOD II (after change)										1,178	1,217
	Percent difference										---	---
Secondary School Teachers	DYNAMOD II (before change)										857	897
	DYNAMOD II (after change)										858	898
	Percent difference										.1	.1

Appendix table C-2.-Results of a one-percent increase in the DYNAMOD II retention rates of secondary school students, by level of schooling or teaching affected, 1959-60 to 1969-70

(Thousands)

		1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
Secondary School Students	DYNAMOD II (before change)	9,271	10,012	10,707	11,309	11,836	12,301	12,709	13,064	13,368	13,622	13,835
	DYNAMOD II (after change)	9,271	10,070	10,811	11,452	12,012	12,505	12,937	13,312	13,633	13,903	14,129
	Percent difference	---	.6	1.0	1.3	1.5	1.7	1.8	1.9	2.0	2.1	2.1
College Students	DYNAMOD II (before change)	3,377	3,762	4,111	4,461	4,807	5,143	5,465	5,769	6,054	6,318	6,559
	DYNAMOD II (after change)	3,377	3,764	4,123	4,486	4,848	5,202	5,543	5,866	6,170	6,451	6,708
	Percent difference	---	---	.3	.6	.9	1.1	1.4	1.7	1.9	2.1	2.3
Elementary School Teachers	DYNAMOD II (before change)						1,041	1,071	1,104	1,140	1,177	1,216
	DYNAMOD II (after change)						1,042	1,072	1,106	1,142	1,180	1,220
	Percent difference						.1	.1	.2	.2	.3	.3
Secondary School Teachers	DYNAMOD II (before change)							745	781	819	857	897
	DYNAMOD II (after change)							746	783	821	861	901
	Percent difference							.1	.3	.2	.5	.4

Appendix table C-3.-Results of a one-percent increase in the DYNAMOD II retention rates of college students, and subsequent effects on teaching levels, 1959-60 to 1969-70
(Thousands)

		1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
College Students	DYNAMOD II (before change)	3,377	3,762	4,111	4,461	4,807	5,143	5,465	5,769	6,054	6,318	6,559
	DYNAMOD II (after change	3,377	3,790	4,165	4,538	4,905	5,260	5,600	5,921	6,221	6,499	6,753
	Percent difference	---	.7	1.3	1.7	2.0	2.3	2.5	2.6	2.8	2.9	3.0
Elementary School Teachers	DYNAMOD II (before change)	952	959	973	991	1,015	1,041	1,071	1,104	1,140	1,177	1,216
	DYNAMOD II (after change)	952	959	973	992	1,016	1,044	1,076	1,110	1,147	1,187	1,228
	Percent difference	---	---	---	.1	.1	.3	.5	.5	.6	.8	1.0
Secondary School Teachers	DYNAMOD II (before change)	580	599	622	649	678	711	745	781	819	857	897
	DYNAMOD II (after change)	580	599	623	650	681	715	751	789	828	869	910
	Percent difference	---	---	.2	.2	.4	.6	.8	1.0	1.1	1.4	1.4
College Teachers	DYNAMOD II (before change)	283	308	332	355	378	401	423	445	466	487	508
	DYNAMOD II (after change)	283	308	332	356	379	402	424	446	468	490	511
	Percent difference	---	---	---	.3	.3	.2	.2	.2	.4	.6	.6

Appendix table G-4. -Results of a one-percent increase in the DYNAMOD II teacher retention rates, 1959-60 to 1969-70
(Thousands)

		1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
Elementary School Teachers	DYNAMOD II (before change)	952	959	973	991	1,015	1,041	1,071	1,104	1,140	1,177	1,216
	DYNAMOD II (after change)	952	967	990	1,014	1,046	1,080	1,116	1,155	1,198	1,242	1,286
	Percent difference	---	.8	1.7	2.4	3.1	3.7	4.2	4.7	5.1	5.5	5.8
Secondary School Teachers	DYNAMOD II (before change)	580	599	622	649	678	711	745	781	819	857	897
	DYNAMOD II (after change)	580	604	632	663	697	734	771	812	853	895	939
	Percent difference	---	.8	1.6	2.2	2.8	3.3	3.5	4.0	4.2	4.5	4.8
College Teachers	DYNAMOD II (before change)	283	308	332	355	378	401	423	445	466	487	508
	DYNAMOD II (after change)	283	310	337	364	390	415	440	465	490	514	538
	Percent difference	---	.6	1.5	2.5	3.2	3.5	4.0	4.5	5.2	5.5	5.9

APPENDIX D

Effects of Variations in the Retention Rates of Students and Teachers

LIST OF APPENDIX D TABLES

APPENDIX D

Effects of Variations in the Retention Rates of Students and Teachers

The student-teacher ratios discussed in table D-1 that are hypothesized to result from a one-percent increase in the retention rates of students or teachers contain a minor degree of noncomparability with the OE base data from which they are calculated. The reason for this is that: (a) an elementary school student in DYNAMOD II is defined as being in grades K through 8, while in OE publications the definition includes only those not attending a junior or senior high school; and (b) DYNAMOD II elementary and secondary school teachers follow the OE definitions exactly. The number of grades 7 and 8 students enrolled in high school organization units (and therefore classified by OE as secondary school students) are about equal to the equivalent of the total 8th grade enrollment in public schools (see OE 10030-66, tables 2 and 3 and OE 10024-65, table 3 plus about 15 percent for nonpublic school enrollments). Thus, about 9-10 percent of the elementary school students affected by a change in the retention rate in DYNAMOD II would fall in the secondary school classification of OE. The main effect, therefore, would be concentrated in the third decimal digit of the retention rate and hence would have only a minor impact on the relative response patterns for the students.

Because of this, and also because the teacher classification in DYNAMOD II follows the OE definitions, it was decided to apply the percent response patterns to one percent changes in the respective student and teacher retention rates from DYNAMOD II to the published OE student-teacher ratios for elementary and secondary schools. The student-teacher ratios shown as Series E base data in appendix table D-1 are combined from the separately published ratios for public and nonpublic schools as shown in OE 10030-66, table 23, using the number of classroom teachers in table 22 as combinatorial weights. The student-teacher ratios for the college sector were computed directly from the DYNAMOD II calculations.

In table D-2, the teacher retention rates were set to the survival rates (1.0000-death rate), and no entries from outside the educational system were permitted. By implication, interlevel transfers (e.g., college teachers switching to secondary school teaching) also were eliminated. No change was made to the flows of college students entering the system.

Appendix table D-1.-Comparison of the variations in the student-teacher ratio caused by selected increases in student or teacher retention rates, by level of schooling, 1959-60 to 1969-70[1/]

	Change in retention rate:	1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1959-70
Elementary school sector	Students: One-percent increase	29.9	29.9	29.7	30.0	29.8	29.4	28.9	28.6	28.4	28.0	27.8
	Series E base data	29.9	29.6	29.4	29.6	29.4	29.0	28.5	28.2	28.0	27.6	27.4
	Teachers: One-percent increase	29.9	29.4	28.9	28.9	28.5	28.0	27.4	26.9	26.6	26.2	25.9
Secondary school sector	Students: One-percent increase	21.2	21.5	21.5	21.6	21.5	21.4	21.4	21.4	21.4	21.5	21.6
	Series E base data	21.2	21.4	21.3	21.3	21.1	21.2	21.0	21.0	21.0	21.1	21.1
	Teachers: One-percent increase	21.2	21.2	21.2	20.8	20.6	20.4	20.2	20.2	20.2	20.2	20.1
College sector	Students: One-percent increase	11.9	12.3	12.5	12.8	13.0	13.1	13.2	13.3	13.3	13.3	13.3
	DYNAMOD II base data	11.9	12.2	12.4	12.6	12.7	12.8	12.9	13.0	13.0	13.0	12.9
	Teachers: One-percent increase	11.9	12.1	12.2	12.3	12.4	12.4	12.4	12.4	12.4	12.3	12.1

1/ Source: Series E base data taken from OE-10030-66, Projections of Educational Statistics to 1975-76. One-percent increase in students and teachers derived from appendix tables C-1, C-2, C-3, and C-4.

Appendix table D-2.-Effects of setting teacher retention rates equal to survival rates while eliminating entries from outside the educational system, by level of teaching, 1959-60 to 1969-70
(Thousands)

		1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
Elementary school teachers	DYNAMOD II (after change)	952	974	1,003	1,037	1,074	1,116	1,160	1,207	1,257	1,309	1,363
	DYNAMOD II (before change)	952	959	973	991	1,015	1,041	1,071	1,104	1,140	1,177	1,216
	Percent difference		1.6	3.1	4.6	5.8	7.2	8.3	9.3	10.3	11.2	12.1
Secondary school teachers	DYNAMOD II (after change)	580	631	687	749	817	889	967	1,050	1,137	1,229	1,324
	DYNAMOD II (before change)	580	599	622	649	678	711	745	781	819	857	897
	Percent difference		5.3	10.4	15.4	20.5	25.0	29.8	34.4	38.8	43.4	47.6
College teachers	DYNAMOD II (after change)	283	290	297	305	314	324	334	345	357	369	383
	DYNAMOD II (before change)	283	308	332	355	378	401	423	445	466	487	508
	Percent difference		-5.8	-10.5	-14.1	-16.9	-19.2	-21.0	-22.5	-23.4	-24.2	-24.6

APPENDIX E

The DYNAMOD II Computer Program

LIST OF APPENDIX E TABLES

APPENDIX E

The DYNAMOD II Computer Program

This appendix consists of four parts: a definition of variables, a flow chart, a FORTRAN program for DYNAMOD II, and a sample output listing. The variables in the FORTRAN program are enumerated and a description of the use of each variable in the program is given in table E-1. An overall flow chart of the model is furnished in figure E-1. 1/

In considering the FORTRAN program for the model several things must be kept in mind. The program listing shown in table E-2 is one that has been run and is operational on the GE Time-Sharing System. Features of the GE Time-Sharing FORTRAN are much more general and flexible than versions of FORTRAN for other computer systems. This can be illustrated as follows. First, notice that at the beginning of each line of the program there is a line number. Thus, a FORTRAN program in GE Time-Sharing FORTRAN consists of enough lines to describe the program. Consequently, there is no restriction (except for space on a line) as to the number of FORTRAN statements per line. Each statement is separated by a semicolon. A second feature not usually available in other systems is the accessing of the program listing in table E-2 is a FILE declaration statement. This affords the convenience of storing the sex/race group matrices that make up the data input to the model in separate files that can be called when needed.

The same program that is listed in this appendix has been run and is made readily available for other systems by putting one FORTRAN statement on each card. The program has been run and tested on a RCA 3301 and an IBM 7094. Listings of these programs along with data are available on request.1/

1/ William K. Winters, DYNAMOD II in a Time-Sharing Environment, Technical Note Number 41, Division of Operations Analysis, National Center for Educational Statistics, Office of Education, September, 1967. Note: This reference gives a more detailed description of the FORTRAN program for DYNAMOD II.

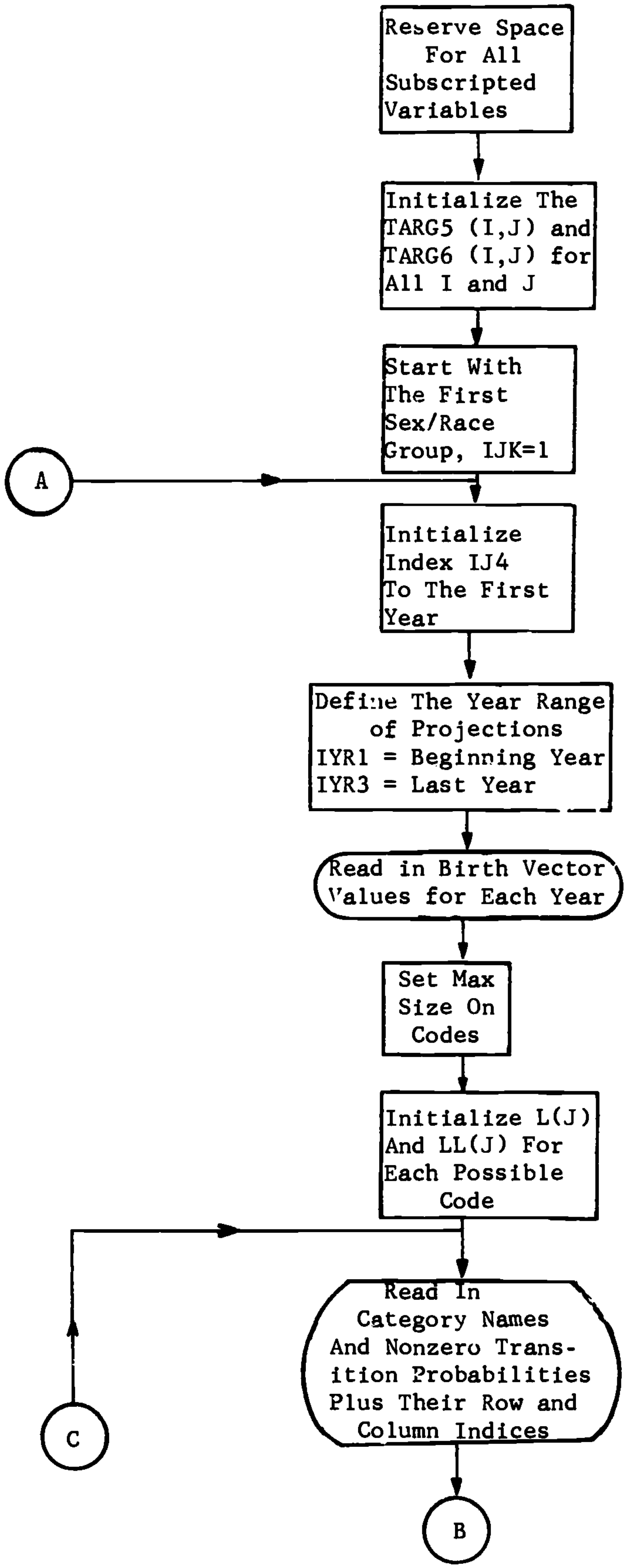
Appendix table E-1.-variables used in the DYNAMOD II FORTRAN program

BARG 5 (IJ1)	-	This variable is used to keep a running tally of the number of individuals projected into the IJ1-th age group for a particular year.
BARG 6 (IJ2)	-	This variable is used to keep a running tally of the number of individuals projected into the IJ2-th student-teacher group for a particular year.
CAT(I,KK)	-	This variable holds the name of the category for the first Ith value of any category. The name is stored in three 6 character chunks, thus the total length of any name can be as large as 18 characters.
CELL (I)	-	This variable retains the number of individuals for the first I-th value of each category when these values are read in from a sex/race group file.
I	-	This variable runs from 1, 2, ... up to a maximum of 220. The index corresponds to the I-th nonzero transition probability read.
IJ4	-	This variable serves as an index to keep track of the year.
IS	-	This variable gives the starting point at which the number of births are added for any year.
IT	-	This variable is the sequence index corresponding to the IYR2-th year we are on.
IT2	-	This variable is used to temporarily store the value of the previous category.
IYR2	-	This variable is the current year index which will contain the value of the year that we are on at any point in the program.
IJK	-	This variable stores the value of each particular sex/race group, that is, IJK = 1 WM 2 WF 3 NWM 4 MWF
L(NTCAT)	-	This variable retains the value of the index I for the first non-zero transition probability read in the NTCAT-th category row.
LL(NTCAT)	-	This variable keeps the value, of the index I, for the last non-zero transition probability read in NTCAT-th category row.

Table E-1 cont'd.

LSIZE	- This variable sets the upper limit on the codes which may be used.
PARMI(I)	- This variable is used to store the value of the I-th non-zero transition probability for a sex/race group.
NCAT(I)	- This variable keeps the value of the column index for the I-th non-zero transition probability read.
NTCAT	- This variable at the point where a nonzero transition probability has just been read has the value of the row category index.
S(J)	- This variable is defined to keep track of the number of births in each of the 10 chosen years: J = 1, 2, ..., 10.
TARG5(IJ4,IJ1)	- This variable keeps a running tally of the number of individuals projected into the IJ1-th age group for the IJ4-th year.
TARG6(IJ4,IJ2)	- This variable keeps a running tally of the number of individuals projected into the IJ2-th occupation group for the IJ4-th year.
TVAL	- This variable retains the total number of individuals across age and occupation groups for any year.
VAL(I)	- This variable retains the number of individuals for the first I-th value of each category.
WT(K)	- This variable keeps the value of the transition probability for the K-th position in any particular row.

Figure E-1.-Flow chart for DYNAMOD II



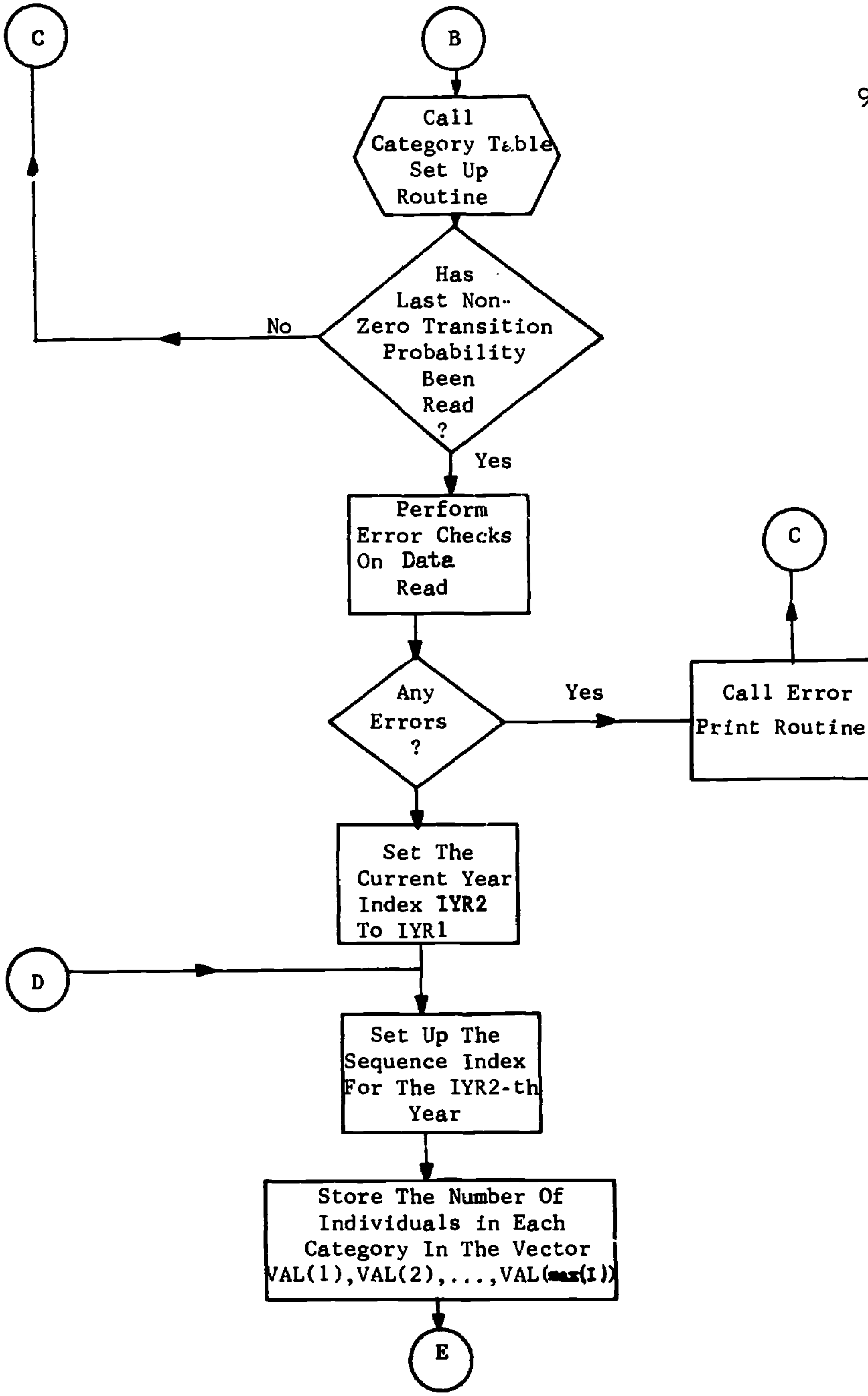


Figure E-1 cont'd.

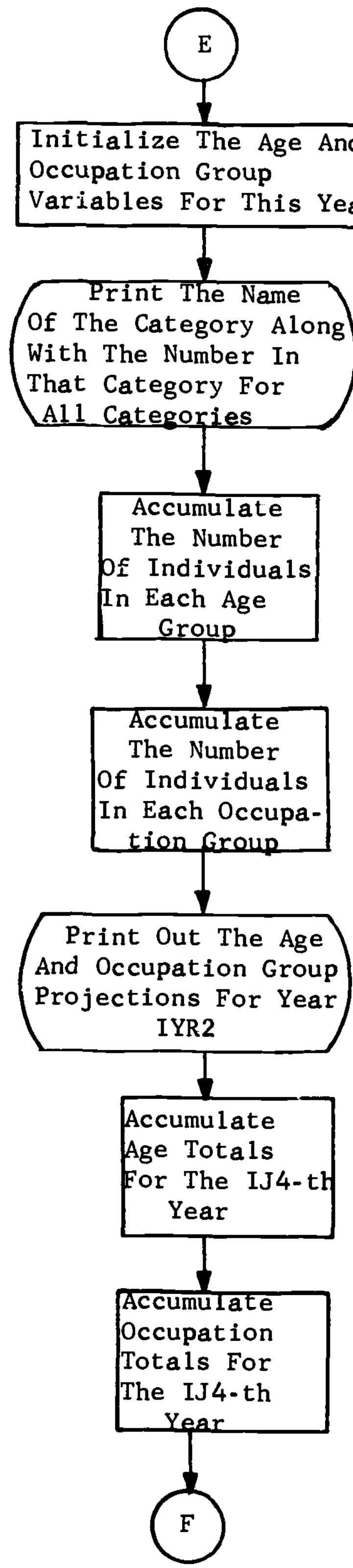


Figure E-1 cont'd.

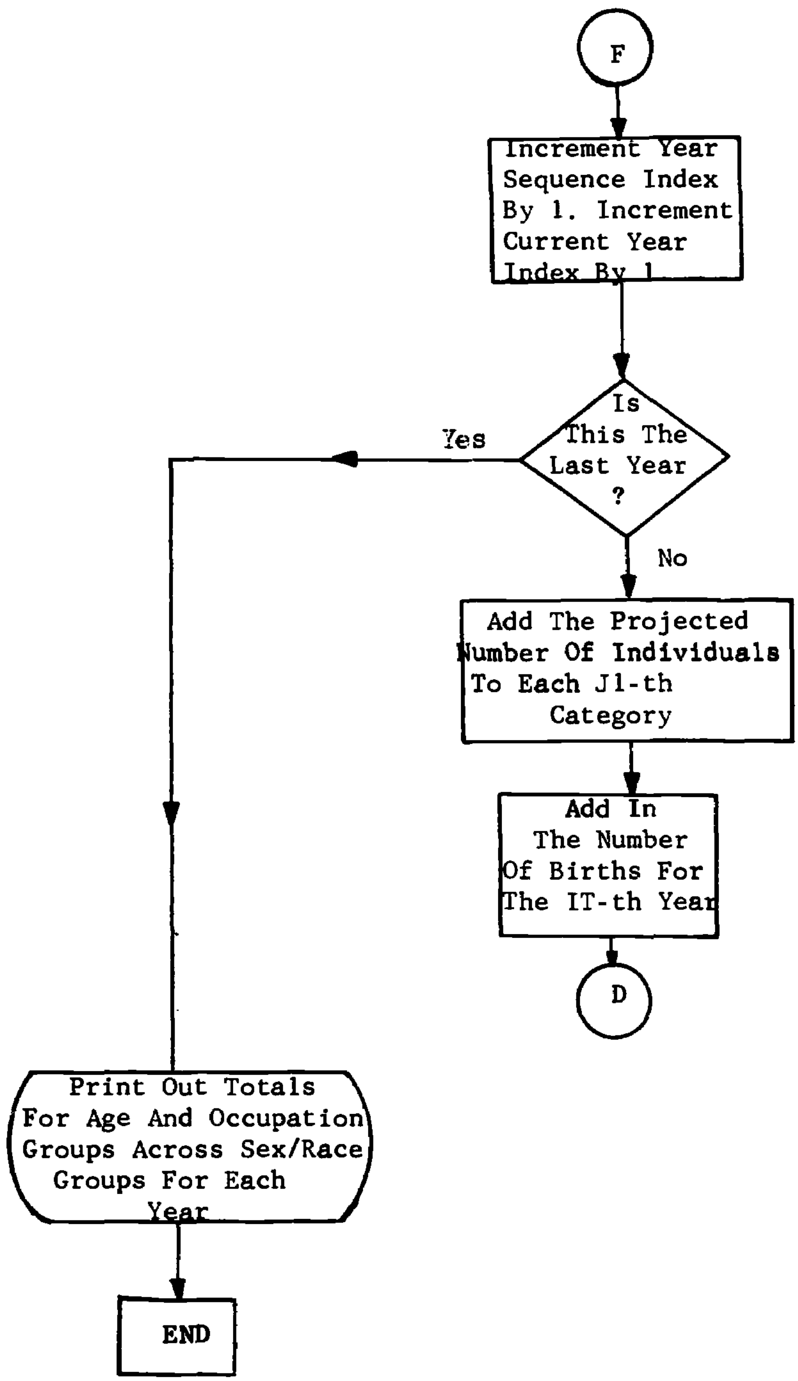


Figure E-1 cont'd.

Appendix table B-2.GE time-sharing FORTRAN program
for DYNAMOD II

```
100 $FILE WM,WF,NWM,NWF
110 DIMENSION S(10),CAT(200,3),VAL(200),CELL(200),PARM1(200)
120 DIMENSION NCAT(200),WT(100),L(99),LL(99),BARG5(10)
130 DIMENSION BARG6(10),TARG5(11,9),TARG6(11,9)
135 DO 340 I=1,11
136 DO340 J=1,9
140 TARG5(I,J)=0.0;TARG6(I,J)=0.0
145 340 CONTINUE
150 DO390IJK=1,4;IJ4=1
155 PRINT,"INPUT DATA FOR SEX/RACE GROUP",IJK,"FOLLOWS"
160 IYR1=1960;IYR3=1970;
170 READ(IJK)IS,(S(J),J=1,10)
175 PRINT,"BIRTH VECTOR ELEMENTS"
180 PRINT,(S(J),J=1,10);LSIZE=99
190 DO1050J=1,LSIZE;L(J)=0;LL(J)=0;1050 CONTINUE;
200 IT2=0;I=1;9 READ(IJK,2)(CAT(I,KK),KK=1,3)
202 2 FORMAT(4X,3A6)
210 10 READ(IJK)NTCAT,CELL(I),NCAT(I),PARM1(I)
218 IF(NCAT(I))6,18,6
220 6 IF(NCAT(I)-99)11,9,11
222 11 IF(NTCAT)15,15,8
223 8 IF(NTCAT-LSIZE)810,810,890
230 810 IF(L(NTCAT))820,820,880
231 820 L(NTCAT)=I
232 IF(IT2)830,830,825
233 825 LL(IT2)=I-1
250 IF(LL(IT2)-L(IT2)-100)830,99,99;830 IT2=NTCAT
260 15 I=I+1;GO TO 10
264 18 LAST=I-1;IF(IT2)99,99,19
270 19 LL(IT2)=I-1;20 IF((IS-1)*(LSIZE-IS))99,23,23;
280 23 IST=IS;IF(L(IST))99,99,25;25 CONTINUE;
290 DO27I=1,LAST
295 260 IF((NCAT(I)-1)*(LSIZE-NCAT(I)))99,262,262
300 262 NCATT=NCAT(I);IF(L(NCATT))99,99,27;27 CONTINUE;
310 28 IYR2=IYR1;30 IT=IYR2-IYR1+1;
320 DO40J=1,LSIZE;I=L(J);IF(I)40,40,38;
330 38 VAL(I)=CELL(I);CELL(I)=0.;40 CONTINUE;
340 PRINT,"NUMBER OF PERSONS IN YEAR",IYR2;
350 DO310IJ1=1,10
354 BARG5(IJ1)=0.0;BARG6(IJ1)=0.0
356 310 CONTINUE
360 TVAL=0.0
370 110 DO150J=1,LSIZE;IF(L(J))150,150,112;
380 112 I=L(J);120 PRINT121,J,(CAT(I,KK),KK=1,3),VAL(I)
390 121 FORMAT(I6,4X,3A6,F12.0)
400 TVAL=TVAL+VAL(I)
410 DO304IJ1=2,10
420 IF(J-IJ1*10)301,304,304
430 301 BARG5(IJ1-1)=BARG5(IJ1-1)+VAL(I);GO TO 302
440 304 CONTINUE
450 302 DO303IJ2=1,9;DO303IJ3=10,90,10;
460 IF(J-IJ2-IJ3)303,305,303
```

Appendix table B-2 cont'd.

```
470 305 BARG6(IJ2)=BARG6(IJ2)+VAL(I);GO TO 306
480 303 CONTINUE;306 CONTINUE;
490 150 CONTINUE
500 160 PRINT161,TVAL
510 161 FORMAT(8H TOTAL =,F12.0)
520 PRINT,(BARG5(IJ1),IJ1=1,9)
530 PRINT,(BARG6(IJ2),IJ2=1,9)
540 D0341IJ1=1,9;
550 341 TARG5(IJ4,IJ1)=TARG5(IJ4,IJ1)+BARG5(IJ1)
560 D0342IJ2=1,9
570 342 TARG6(IJ4,IJ2)=TARG6(IJ4,IJ2)+BARG6(IJ2)
580 IJ4=IJ4+1;180 IYR2=IYR2+1;
590 IF(IYR2-IYR3)200,200,500;200 CONTINUE;
600 D0300J=1,LSIZE;IF(L(J))300,300,215
610 215 IT1=L(J);IT2=LL(J);TWT=0.;
620 220 D0225I=IT1,IT2;K=I-IT1+1;
630 WT(K)=PARM1(I);TWT=TWT+WT(K);
640 225 CONTINUE
650 230 D0235I=IT1,IT2;K=I-IT1+1;
660 J1=NCAT(I);J2=L(J1);
670 CELL(J2)=CELL(J2)+WT(K)*VAL(IT1)/TWT
680 235 CONTINUE;300 CONTINUE;
690 J=L(IS);CELL(J)=S(IT)+CELL(J);
695 PRINT,"J = ",J," CELL(J) = ",CELL(J)
700 400 GO TO 30
705 880 PRINT,"NTCAT = ",NTCAT,"I = ",I,"  880"
710 GO TO 15
715 890 PRINT,"NTCAT = ",NTCAT, "I = ",I,"  890"
716 GO TO 15
720 99 PRINT,"NTCAT = ",NTCAT,"I = ",I,"CATEGORY IS "
725 PRINT,(CAT(I,KK),KK=1,3),"NCAT(",I,") = ",NCAT(I)
730 500 CONTINUE;390 CONTINUE
740 PRINT,"TOTALS FOR CODES";
750 IJ5=IYR1-1;D0346IJ4=1,11;
760 IJ5=IJ5+1;
770 PRINT,(TARG5(IJ4,IJ1),IJ1=1,9),IJ5;
780 PRINT,(TARG6(IJ4,IJ2),IJ2=1,9);
785 346 CONTINUE
789 $OPT SIZE
790 END DYNAMOD
```

Appendix table E-3.-Sample output listing of DYNAMOD II

```
INPUT DATA FOR SEX/RACE GROUP        1FOLLOWS
BIRTH VECTOR ELEMENTS
     1878.00       1834.00       1798.00       1772.00       1687.00
     1608.00       1658.00       1724.00       1790.00       1858.00
THE YEAR IS      1960
    11     0-4 ELEM. STUDENT           145.
    19     0-4 OTHER                  7955.
    21     5-14 ELEM STUDENT         15314.
    22     5-14 SEC. STUDENT          1012.
    27     5-14 ELEM DROP-OUT           14.
    28     5-14 SEC. DROP-OUT           10.
    29     5-14 OTHER                 1703.
    31     15-19 ELEM STUDENT          381.
    32     15-19 SEC. STUDENT         4928.
    33     15-19 COL. STUDENT         1185.
    37     15-19 ELEM DROPOUT           83.
    38     15-19 SEC DROP-OUT          430.
    39     15-19 OTHER                 943.
    41     20-24 ELEM STUDENT           38.
    42     20-24 SEC. STUDENT          184.
    43     20-24 COL. STUDENT         1367.
    44     20-24 ELEM TEACHER           24.
    45     20-24 SEC. TEACHER           77.
    47     20-24 ELEM DROPOUT             .
    48     20-24 SEC. DROPOUT          118.
    49     20-24 OTHER                4758.
    51     25-44 ELEM STUDENT           34.
    52     25-44 SEC. STUDENT          147.
    53     25-44 COL. STUDENT          802.
    54     25-44 ELEM TEACHER          108.
    55     25-44 SEC. TEACHER          231.
    56     25-44 COL. TEACHER          179.
    57     25-44 ELEM DROPOUT            2.
    58     25-44 SEC. DROPOUT            8.
    59     25-44 OTHER               18574.
    64     44+UP ELEM TEACHER           49.
    65     44+UP SEC. TEACHER           99.
    66     44+UP COL. TEACHER          132.
    69     44+UP OTHER               24340.
    70     DEAD                       6125.
 TOTAL =       91499.
    8099.6475    18051.834     7949.6002    6567.0374    20086.292
   24619.348     6125.2408     0.00          0.00
   15911.428     6270.9627     3353.8529     181.5838      407.3868
    311.7133       99.3819      565.0989    58272.351
```

A sample listing of the output from the DYNAMOD II program is presented in appendix table E-3. The data from a particular sex-race group is announced as "i follows," where i represents the codes used for the sex-race groups: 1 stands for white males, 2 for white females, 3 for nonwhite males and 4 for nonwhite females.

Next, the number of births in the years 1961, 1962, etc. up to 1970 are printed. All numbers are in thousands so, for example, if one sees 1878.00 this should be interpreted as 1,878,000. Starting at the left and moving right for each row the numbers printed are associated with consecutive years; that is, 1878.00, 1834,00, etc., are associated with the years 1961, 1962, etc.

The year to be printed out is announced and for each category code a shortened form of its meaning is printed along with the number of individuals for that year that are in the category. The numbers are again in the thousands. For example,

11 0-4 ELEM. STUDENT 145

is interpreted as follows: the category code 11 stands for the category of 0 to 4 year old elementary students which has for the year 1960 145,000 students. At the end the total number of individuals for the year is printed in thousands.

The next set of numbers are preselected subtotals and

are interpreted as follows: For each year the number of projected individuals in the age grouping and in the occupation grouping are printed separately. So in the above four rows of numbers the following correspondence is made to interpret the numbers correctly. Starting with the left-most number in the first row and moving successively to the right in each row for two rows, the integers 1, 2, 3, 4, 5, 6, 7, 8, 9 are associated with each of the numbers. Then the meaning of each of the integers is as follows:

8099.6475	18051.834	7949.6002	6567.0374	20086.292
24619.348	6125.2408	0.00	0.00	
15911.428	6270.9627	3353.8529	181.5838	407.3368
311.7133	99.3819	565.0989	58272.351	

1	0	-	4	years
2	5	-	14	"
3	15	-	19	"
4	20	-	24	"
5	25	-	44	"
6	44+			"
7	Dead			

For the example above the number of 0-4 year olds is 8,099,648. The number 44 years old and older is 24,619,348.

Next, in the third and fourth rows we can associate the integers 1, 2, 3, 4, 5, 6, 7, 8, 9 with each of the following categories:

1 Elementary school student
2 Secondary school student
3 College teacher
4 Elementary school teacher
5 Secondary school teacher
6 College teacher
7 Elementary school dropout
8 Secondary school dropout
9 Other

After the data for the individual sex-race groups (including their respective subtotals) have been obtained, provisions are available for taking subtotals, by year, over all four sex-race groups. The format is the same as for the subtotals for the individual groups shown above.

APPENDIX F

METHODOLOGY OF PARAMETER ESTIMATION IN DYNAMOD II: AN ANNOTATED BIBLIOGRAPHY

The list of technical notes presented below discuss in depth the parametric estimating procedures and data sources used in the development of DYNAMOD II. The abstractor's names appear in parentheses at the end of the abstract.

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Birth and Death Inputs

TN-11 BIRTH AND DEATH PROJECTIONS USED IN STUDENT-TEACHER POPULATION GROWTH MODELS. Tetsuo Okada, November 14, 1966

This note presents a brief description of the methodology used to project births and deaths in DYNAMOD II (See TN-34). For death rates, the most recently available data (1964) by sex and race was used and assumed to be constant over the period of projection. For projected number of births, Grabill's marriage-parity-progression method was employed. This method takes account of the variables of marriage, parity (number of previous children born), and birth interval (time between marriage and successive children). (T. Okada)

First-Stage Trial Estimates

TN-28 DROPOUT AND RETENTION RATE METHODOLOGY USED TO ESTIMATE FIRST-STAGE ELEMENTS FOR DYNAMOD II. Edward K. Zabrowski and John T. Hudman, April 20, 1967

DYNAMOD II is a computerized Markov-type demographic model of the time flows of the educational population (See TN-34). The model was built in two stages: in the first stage, the population was divided into male and female, and the transition probabilities for the respective educational groups were estimated. In the second stage, these probabilities were factored further to develop sex-race-age-educational category parameters. This note concentrates primarily on the procedures used in estimating the male/female flow parameters (transition probabilities) for elementary, secondary, and college students. Estimating formulas and data sources are given. An appendix is devoted to secondary school students' dropout rates. The estimating procedures used for the remaining transition probabilities is discussed in TN-24 and TN 39. (E. Zabrowski)

TN-39 METHODOLOGY USED TO ESTIMATE FIRST-STAGE ELEMENTS OF THE TRANSITION PROBABILITY MATRICES FOR DYNAMOD II: TEACHERS AND EXTRA-SYSTEMS FLOWS. Edward K. Zabrowski, September 18, 1967

This note is essentially a continuation of the exposition of the transition probability estimation procedures first discussed in Technical Note Number 28. The procedures developed describe how estimates were obtained of the chances that a person in a given educational category in one year (e.g., male college students) will move to another educational category by the next year (e.g., male elementary school teachers). Specifically discussed in the development of the probabilities that college students will enter elementary, secondary or college teaching; that a teacher in one level in a given year will transfer to another level of the next year (e.g., that college teachers will transfer to secondary school teaching); and that persons outside the educational system will enter one of the pre-defined educational levels: elementary, secondary or college students and elementary, secondary or college teaching. All estimates were developed from various documented sources. (E. Zabrowski)

Final Stage Trial Estimates

TN-12 ESTIMATION OF AGE TRANSITION PROBABILITIES. Judith R. Zinter, December 8, 1966

This note describes the procedure followed in estimating age transitions for DYNAMOD II, a computerized Markov chain model characterizing the flow of students and teachers through the educational system over time (See TN-34). The age transitions are presented in the form of probability matrices, one for each sex-race group. By means of these matrices, one can find the probability that an individual will (1) remain in a given age group, (2) move into the next age group, or (3) die. The age groups for which transition probabilities are estimated are 0-4, 5-14, 20-24, 25-44 years old, and 44 years old and over. (J. Zinter)

TN-40 ESTIMATION OF SECOND-STAGE DROPOUT RATES FOR STUDENT-TEACHER POPULATION GROWTH MODEL (DYNAMOD II). Judith R. Zinter, August 28, 1967

This note presents the methodology used to estimate dropout rates for DYNAMOD II, a computerized Markov chain model of student and teacher flows over time (See TN-34). Dropout rates are estimated for elementary and secondary students by race and sex for the following age groups: less than 15, 15-19, 20-24, and 25-44 years of age. (J. Zinter)

TN-42 TRANSITION PROBABILITIES FOR STUDENT-TEACHER POPULATION GROWTH MODEL (DYNAMOD II). Judith R. Zinter, September 18,1967

This note lists the transition probabilities in use in DYNAMOD II as of the date the note was published. These transition probabilities are estimates of the chance that an individual in a given sex-race-age-educational level category in one year will move to another feasible category by the following year. (J. Zinter)

Computing Methodology

TN-45 DYNAMOD II IN A TIME-SHARING ENVIRONMENT. William K. Winters, October 23, 1967

This note describes in detail the development of the FORTRAN computer program for the Student-Teacher Population Growth Model (DYNAMOD II), a model of the flows of students and teachers over time. (See TN-34). The program is written for use on the GE-235 Time-Sharing System. Flow charts of the source program and definitions of the program variables are included in the note as well as complete listings of the source program and data files and sample listings of output. (J. Zinter)

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