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ABSTRACT

The Simulation Option Model (SOM) was developed as part of the Centre for Educational Research and Innovation work on educational planning. Its two main purposes are to be an analytical tool for the project on Educational Growth and Educational Opportunity and to be a direct contribution to member countries' own work in these areas. The model includes predictions about future numbers of students in various parts of the system and outflow from the educational system; future resource requirements, both physical and monetary; future supplies of teachers in various categories; and future relationships between teacher supply and teacher requirements. The paper provides a brief overview of the model's submodels--flow, resource, teacher supply, and teacher comparison--and of an application study. Appendixes provide more detailed information, including flow charts. (Author/IRT)

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Centre for Educational Research
and Innovation

Paris, 10th March, 1970

CERI/EG/DM/70.01

S.O.M. - A SIMULATION MODEL OF THE EDUCATIONAL SYSTEM

- Introduction -

1. The Centre's activity on Educational Growth and Educational Opportunity is composed of three inter-related projects: (i) alternative strategies now available, or feasible in the future, for maximising the performance of educational systems in terms of equality of opportunity; (ii) strategic decision-making problems; and (iii) alternative educational futures.

2. The Centre is, therefore, interested in examining the place and the weight of educational planning in the total decision-making structure in order to see whether a closer integration is feasible. Given the nature of the present activity, the central focus remains, of course, decision-making problems related to alternative strategies for equality of opportunity.

3. One aspect of this work is inevitably concerned with educational planning techniques. Here attention will be focused on educational planning problems with, for example, important budgetary consequences and on the investigation to what extent systematic qualitative and quantitative analysis can improve the decision-making basis. It is in this context that the attached simulation model, SOM (simulation option model) has been prepared. This model has been specially designed so as to be able to deal with different transition coefficients for different social groups and with a wide range of different structures of the educational system. In principle, the model estimates future student stocks, the outflow from the various levels, as well as real and monetary resources requirements. It can, therefore, be of real use in a first exploration of the consequences and implications of alternative educational strategies.

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4. The model partly originated from the work on the preparation and evaluation of the O.E.C.D. Meeting on "Budgeting, Programme Analysis and Cost-Effectiveness in Educational Planning", in April, 1968 *, under the Programme of the Committee for Scientific and Technical Personnel. It was apparent from the papers presented at this Meeting that the introduction of programme budgeting for long-range planning purposes could be facilitated by the use of programme-oriented cost models.

5. The main purpose of SOM is twofold:

(i) it will be an analytical tool for the CERI project on Educational Growth and Educational Opportunity as specified above;

(ii) it can also be seen as a direct contribution to Member countries in their own work. Perhaps, after some adjustments, it can either be directly applied by them or provide some general information about data needs for various educational planning problems and about the virtues and drawbacks of these kind of models.

6. The attached paper contains only Part I of the project. Part II, which presents a technical description of the computer programmes, is available in limited numbers upon request.

7. The SOM project was carried out by Dr. Brita Schwartz in collaboration with Mr. Marc Nuizière and Mr. Tor Kobberstad. Mr. Michel Martin contributed to the computer programme and to the connection of subprogrammes into a system. Mr. Stephen Centner and Mr. Ron McDougall took part in the earlier stages of the work.

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* See the O.E.C.D. publication under the same name, Paris, 1968, p. 5.

TABLE OF CONTENTS

SOM - A Simulation Model of the Educational System

PREFACE

The simulation model SOM (Simulation Option Model) is meant as a tool for conditional predictions of the development of the educational system. Part I of this report presents a general description of the project. Part II is a technical description of the computer programmes for the users of these programmes.

PART I

SOM - The Simulation Option Model

1. Introduction

The simulation model SOM (Simulation Option Model) is meant as a tool for conditional predictions of the development of the educational system. It includes predictions about:

(a) future numbers of students in various parts of the system and outflow from the educational system;

(b) future resource requirements, both physical requirements (such as various categories of teachers and school-building resources) and corresponding monetary requirements;

(c) future supply of teachers for various categories of teachers;

(d) future relationships between teacher supply and teacher requirements.

Before we enter into the description of the model, we will make some general comments on the model concept and the role of models in analyses of educational planning problems.

The model concept

A model is usually defined as a theoretical description of certain aspects of a real life process or system. The choice of characteristics taken into account, as well as the degree of accuracy aimed at depend, of course, on the types of problems for which the model has been designed.

We can take as an example a model describing the flow of pupils and students through the educational system. Such a model defines the relationships between the present stock in various grades or levels or branches; future inflow of new enrolments into the system, transition coefficients and future stocks and outflows from the system. The transition coefficients may here be estimates based on present trends or any kind of assumed values, the consequences of which one wants to examine. Some examples of this type of model are presented in Part II of reference /1/, see for instance the article by Armitage-Smith. The characteristics of the educational system that a flow model takes into account are student flows and student numbers, while

/1/ Mathematical Models in Educational Planning, O.E.C.D., Paris, 1967.

other characteristics, such as resource requirements, curricula, etc. are omitted. Such other characteristics can be left out when one wants only to examine the relationship between transition coefficients and future stocks and outflows from the system.

Depending on their structure and on the features emphasised, models can be classified along a number of different lines. One may, for instance, distinguish between analytical and simulation models, stockastic and deterministic models, manual and computerised models, descriptive and forecasting models, etc. They may also be divided:

(a) according to the process or system they embrace. Educational models are descriptions of internal relationships within the educational system, economic-educational models are descriptions of the relationship between the development of the economy and the educational system. Models including relationships concerning a specific educational branch, school or institution may be termed institutional models;

(b) according to the specific characteristics of the process they emphasise; hence the origin of such terms as student flow model, resource implication model, cost model, cost-effectiveness model, economic development model, etc.;

(c) according to the level of disaggregation or the decision-making level they concern (macro or micro models, national or regional models, etc.).

SOM is an example of an educational model. It contains several submodels, for instance a flow submodel and a resource implication submodel. An example of an institutional model is the university resource implication model CAMPUS, presented by R. Judy et al in reference [2]. Economic-educational models are of potential interest when the satisfaction of manpower requirements is considered an important educational objective. Some examples of such models are those developed by Tinbergen [3], Adelman [4], Bowles [5], and Bénard [1]. Because of the aggregate description of the educational system and the significance of other educational objectives than the satisfaction of manpower requirements, results from the application of economic-educational models have to be supplemented with further analyses of the educational system before information of direct relevance to the educational decision-maker can be obtained

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[1] Mathematical Models in Educational Planning, OECD, Paris, 1967.

[2] Budgeting, Programme Analysis and Cost-Effectiveness in Educational Planning, OECD, Paris, 1968.

[3] Econometric Models of Education, OECD, Paris, 1965.

[4] "A linear programming model of educational planning" by I. Adelman in "The Theory and Design of Economic Development" ed. by Adelman and Thorbecke.

[5] "The efficient allocation of resources in education", by S. Bowles in the Quarterly Journal of Economics, May, 1967.

The role of mathematical models

Somewhat more complex mathematical models usually take a long time to develop. This effort is, of course, wasted if they require input data which are neither available at present nor likely to be so in the future. This does not mean that models have to be based exactly on presently available statistics. An advantage of the development and use of models may, in fact, be that they give a deeper insight in what data are the most important ones for obtaining information relevant to educational planning problems. Priorities in the statistical data collecting work can thus be established.

It is unrealistic to believe that a model can be made so general and at the same time so detailed that it can produce all quantitative information needed by educational planners. A combination of different methods, models and approaches will always be needed. An important phase in the use of the model must, therefore, be the evaluation of the results, consideration taken to uncertainties in input data and the simplifying assumptions on which the model is based. If these assumptions are insufficiently known by the user or if the results are not critically examined, the use of models may do more harm than good.

An advantage of models, computerised models in particular, is that they make it possible to examine many alternatives and to test the sensitivity of the results to uncertainties in input data.

The development of SOM was preceded by a study of the educational planning problems in Member countries as presented in the O.E.C.D. country reports and an evaluation of the extent to which this type of model could contribute to the provision of information of importance for these problems. There seemed to be a general need for tools for studying the long-term aspects of resource requirements and teacher supply and demand problems, specifically if such tools could facilitate the investigation of many different alternatives and analyse the sensitivity of the result to the uncertainties in data. These findings were the general guide-lines for the construction of SOM.

The main features of SOM are outlined below. As an illustration, an application study is presented in paragraph 7 and in Annex 5. Details concerning each of the submodels are given in appendices. A technical description of the computer programme is presented as Part II of this report.

2. Description of SOM

SOM is a time-step simulation model which simulates the flow through the educational system and forecasts during a future period of time, say 10-20 years, educational output and teacher supply as well as educational resource requirements, i.e. teacher demand, building space requirements and educational expenditures. The estimates are made for each year of a future period of time, that is the basic time-step unit is one year.

In various countries a number of models for the same type of estimates have been developed, for instance flow models for predictions of future number of students (reference /1/ p. 6). Some resource or cost models are described in reference /2/ p. 6. (See, for instance, the articles by K. Hüfner & E. Schmitz and R. Judy et al, respectively.)

The SOM project can be seen as an effort to integrate these earlier model developments into one model system. Special emphasis has been laid on flexibility in order to make the same model fit the educational systems of different countries, but also to enable the users in each specific country:

(i) to apply it to studies involving changes in the structure of the educational system;

(ii) to vary the level of disaggregation in accordance with the requirements of the problem under study;

(iii) to exclude part of the model when not needed, so as to reduce the amount of input data required.

The desired flexibility has been obtained by making the model in the form of a computerised simulation model and designing it in a way which takes advantage of recent developments as to the use of computers. The fact that the model has been programmed for a computer facilitates investigations of many alternatives. One can, for instance, study the influence that variations of uncertain input data and various policy variables may have on the output (sensitivity analysis).

The SOM is "neutral" with regard to priorities between educational objectives, since it merely simulates the development of the system on the basis of various assumptions or estimates of such factors as transition coefficients, demographic developments, restricted entry or other resource restrictions, relationships between physical and financial resources, etc. It can thus be seen as a kind of "what-if" model, in which the effects of considered changes are traced through the educational system. It is, for instance, designed so as to be able to answer such questions as: "What consequences concerning the educational outflow and educational resource requirements will we get if this transition coefficient increases over time in this way, or if class size is changed so and so much?" It follows from the comments above that SOM transforms basic statistical data to information of somewhat more direct interest to the decision-maker when the satisfaction of social demand is an objective of interest. In principle, SOM can be considered as a "forward running" model as it is based on the present state of the educational system and provides conditional forecasts of its future development. When the satisfaction of manpower requirements is of interest, studies are needed for the estimate of such future requirements and their implications for the educational system. This requires a kind of "backward running" approach which starts with future target values and traces the consequences of these back to the present state.

This backward running approach must normally be combined with a forward running approach if one wants to examine implementation possibilities, and evaluate different strategies in more detail. This is specifically the case when a compromise between different educational objectives is sought.

The construction of the model is based on the following general assumptions about the structure of the educational system and the pupil flow through it:

(1) The educational system is assumed to consist of a number of educational "boxes" or "units". A unit is a form or grade consisting of a number of classes; resource requirements and transition coefficients are specific for each unit. Different branches can be distinguished between by giving their grades different sets of numbers (cf. diagram 1). A distinction between branches is not needed in aggregated studies, but is necessary when separate estimates are needed for the future stocks, or resource requirements of each branch.

(2) The educational system may be divided into a number of levels in such a way that the pupils enter the first level of the system and then successively proceed to higher levels.

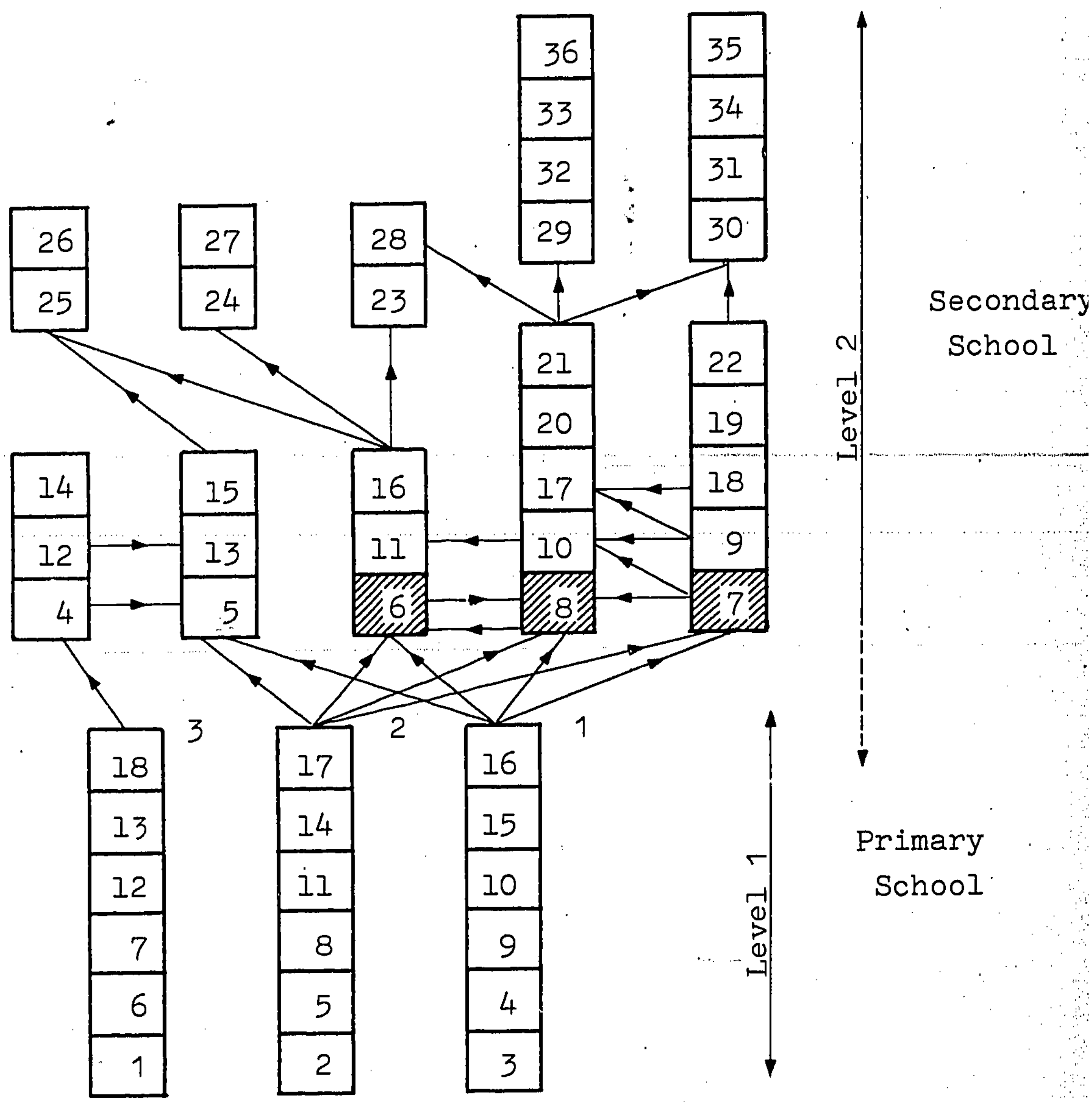
(3) Each year there are the following possibilities for the flow of pupils:

a) repetition of the same unit;
b) drop-out without an examination;
c) leaving school with an examination;
d) continuation to another educational "unit" which may be the next grade or branch.

(4) Certain educational units may have restricted entry. This restriction is expressed in the number of places available each year.

An example of a description of a school system by educational units is outlined in diagram 1. The shaded areas are units with restricted entry. Arrows illustrate pupil flows. From each unit there may be a flow to any of the other units. The transition coefficient from unit I to unit J is defined as the ratio of pupils who move from unit I to unit J. This coefficient may vary over time. The model provides for a disaggregation of the pupils in different groups, for instance, according to socio-economic background and sex. The pupils are assumed to remain in the same group during the time they stay in the educational system. The groups are distinguished by different sets of transition coefficients. The number of pupil groups is a parameter, allowed to vary between 1 and an upper limit. (This limit has been chosen equal to 4 in the present computer programme.) As summary results are calculated for each level, it is most convenient to define the different levels in a way corresponding to the organisation of the educational system, for instance: Level 1 may be Primary School, Level 2 Secondary School, etc. Other ways of defining levels can also be used.

DIAGRAM 1



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Level 2
Level 1
Secondary School
Primary School

For technical reasons the system has to be divided up into levels if one wants to disaggregate it into more than "N" educational units. (N = 40 in the present computer programme, which has been designed to fit a medium size computer - IBM 360/30). Larger "N" values may be used if a larger computer is available or if only part of the model is used. The division into levels should then be made so that no level consists of more than "N" units. The units in one level from which there is a flow to a higher level are given two numbers: the highest unit numbers of the lower level, and the lowest numbers of the higher level (cf. diagram 1).

SOM consists of four submodels each of which will be described separately below:

1) Flow submodel
2) Resource submodel
3) Teacher Supply submodel
4) Teacher Comparison submodel

3. Flow Submodel

The Flow submodel calculates from year to year the student stock in the educational system and the outflow from it (drop-outs and school leavers with exams). The calculations are based on the existing stock in each grade, transition coefficients and the number of available places in case of restricted entry. The model is different from earlier models forecasting student numbers in the following respects:

(i) the way restricted entry is taken into account;

(ii) the lack of restrictions on how the transition coefficients vary over time. Earlier flow models usually assumed that they remain constant over time;

(iii) the high degree of disaggregation which is possible even if a small computer is used (about 200 units for 360/30. This high disaggregation has been obtained by the division of the system by levels). As a unit corresponds to one school year in a branch it is thus possible to distinguish between a number of different branches if one wants to. The degree of disaggregation is optional, i.e. it can be chosen each time the model is used;

(iv) the pupils may be divided according to sex and socio-economic background. To use this possibility, stock data and transition coefficients must, of course, be known separately for each group.

The Flow submodel is based on the following categories of input data:

(i) Demographic and school entry data;

(ii) Student stock in the "base" year (year 0). The years are counted as school years or academic years, i.e. in most countries they start and end in the middle of the calendar year.

(iii) Transition coefficients for each unit (and pupil or student group). These coefficients may change over time in a non-linear way. If the change is linear over a certain time interval only the coefficients corresponding to the ends of the interval are read as input. The programme then calculates the internal values by linear interpolation.

(iv) Restricted entry data. For each level input information is needed about which units are restricted and about the number of places supplied in each of them.

The calculations carried out in the Flow submodel for each year of the simulated time interval are described below:

A. New Enrolments

The number of new enrolments from outside the educational system is calculated from demographic forecasts and school entry data. The demographic data are expressed as the estimated number of children of school entry age for each simulation year. If the school entry age covers several age groups, this can also be taken into account.

We have assumed that there are only new enrolments into Level 1. In practice, it may, of course, also happen that levels other than the first one receive new enrolments from outside the educational system. These consist either of immigrants or students who restart their studies after having left the educational system a year or more earlier. This can be taken into account in the model by the use of fictitious units, that is, units without any resource requirements, but associated with stocks and transition coefficients.

B. The Outflow from the System

We distinguish between two categories of outflows, namely:

(i) "school-leavers", who leave the school system with an "exam", that is, after having successfully completed the unit to which they belonged;

(ii) "drop-outs", who leave school during the school year or at the end of it without having an "exam" or without having acceptably completed the unit.

The number of school-leavers and drop-outs from each unit is directly obtained by multiplying the stock by the corresponding transition coefficients. However, the number of school-leavers thus calculated may differ from the real value in the case of restricted entry. If there is a flow of pupils from a unit J to one or more restricted units but to no "open" units the number of school-leavers from J may change after the allocation of the restricted places. This change is calculated in the restricted entry section of the model.

C. New Stock

In general, the new stock in year T in a unit is obtained as the sum of the number of repeaters and the flows from other units. However, in the case of restricted entry this sum may differ from the number of available places. In this case the preliminary stock value is corrected and the pupils are "redistributed" according to the principles outlined below.

D. Redistribution in case of Restricted Entry

Restriction of the supply of places usually affects the flow through the system in a complex way, as there is interaction between many different factors such as:

(i) admission principles;

(ii) distribution of pupils' priorities and qualifications, and interrelationships between these factors;

(iii) supply of places in the restricted units;

(iv) number of pupils in the "source" units, i.e. the units from which there is a flow to restricted units.

Information on (i) and (ii) is, however, usually incomplete and not available in a form applicable for prediction purposes. The simulation method we have chosen assumes information to be available about the "observed" transition coefficients for a previous year. These coefficients do not give any direct information about the real demand for places, but are a combined result of the present relationships between admission principles and pupils' qualifications, and between supply and demand.

The following assumptions have been made:

(a) The supply of places in the restricted units is so small in comparison with the demand by those eligible that the places will always be filled. (If this is not the case we cease to call them restricted units).

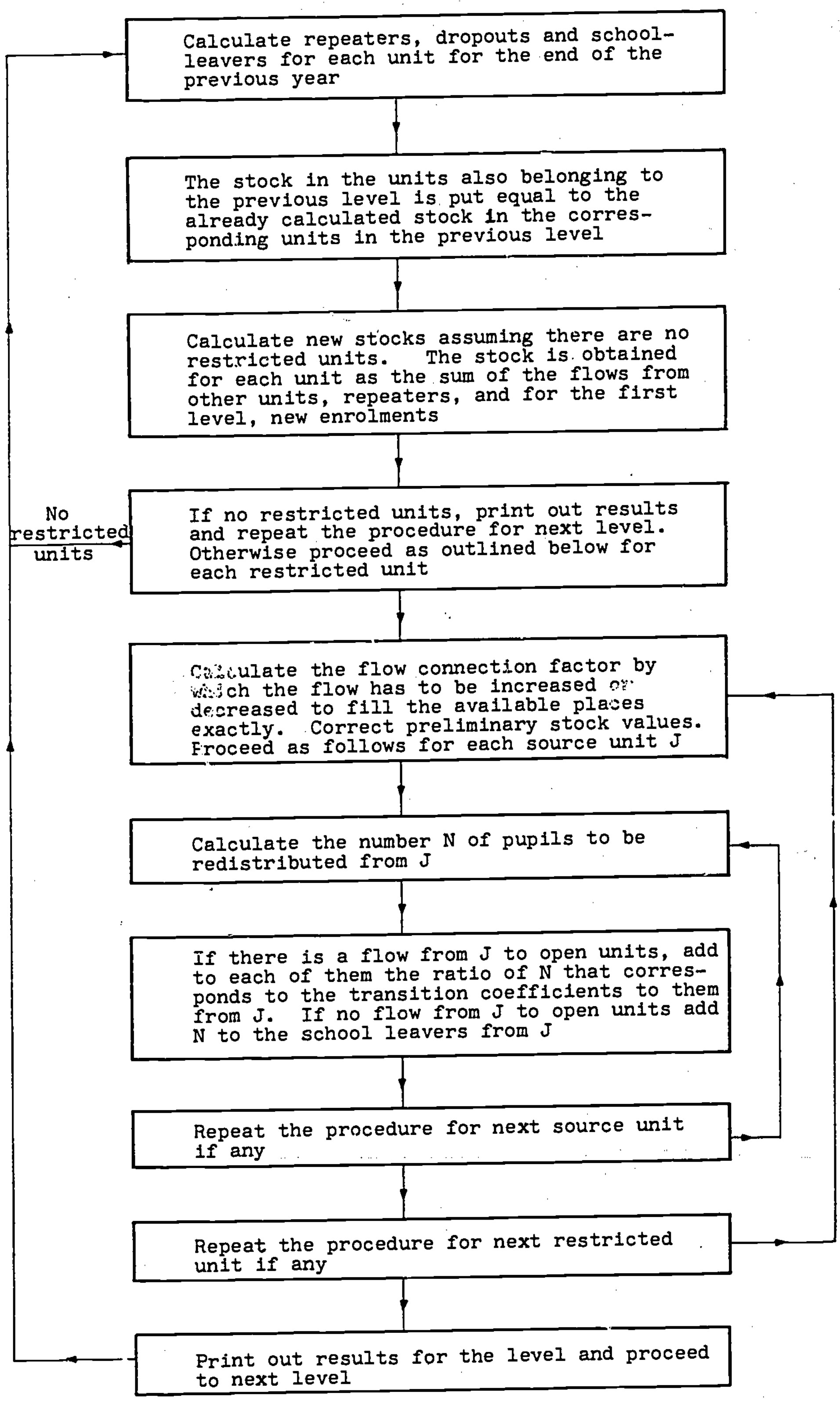
(b) If the flow from a source unit J only goes to restricted units those who are not accepted are assumed to leave school.

(c) Those who are not allowed into any restricted units choose an "open" unit if there is a flow from the source unit to an open unit.

(d) If there is a flow from unit J to several "open" units, those who are not admitted to restricted units are distributed between the open units in proportion to the original transition coefficients.

(e) The allocation of the restricted places between students from competing units is proportional to the original flow.

BLOCK DIAGRAM FOR THE FLOW SUBMODEL



The block diagram for the Flow submodel presents a survey of the organisation of the calculations. The operations are carried through for each Level L and each simulation year.

A more detailed description of the calculations, input data and calculated quantities appears in Appendix 1.

4. Resource submodel

The resource submodel is essentially supplementary to the running of the model, i.e. SOM can be used excluding the resource submodel. The resource submodel accepts as inputs pupil stocks, school curricula and information on resource utilisation. It calculates resource requirements and current expenditures for each educational unit and for each level. Required investments and corresponding capital costs are calculated for certain groups or blocks of units within each level, (i.e. for certain blocks of units which can be assumed to share resources), and for each level.

The model organises data and looks at the system in a different way from the traditional accounting model; costs are "built up" rather than broken down yearly from total cost figures. Cost calculations are based on calculated physical resource requirements for each unit or block of units and added up according to a number of different categories, for instance for each educational activity (subject or group of subjects) and for different parts of the school system. The model can thus be made to produce a programme budget where a number of alternative definitions of programmes may be used.

The resource calculations are based on the total pupil stock in each unit. This stock is calculated in the Flow submodel for each year. The model distinguishes between two types of resources. The <u>direct</u> resource requirements are those directly generated by the teaching function; they consist of teachers, class-rooms and special rooms, and various types of equipment. The <u>indirect</u> resource requirements are those caused by various auxiliary functions, such as administration, medical and social services, libraries, scholarships, and subsidies paid out to students or pupils.

To continue the description of the Resource submodel we first need to introduce some concepts and classification principles.

Activity

Each educational unit is assumed to have a certain curriculum consisting of one or more "activities". An activity can be a subject, a group of subjects or the entire curriculum, depending on the aggregation wanted. The length of an activity is defined as the average number of weekly hours during the school year. The activities are classified by code numbers.

In primary school the different subjects usually cause the same resource load per hour taught, as the same type of teacher and class-room is used.

It may thus be unnecessary to deal with the different subjects separately. In this case all the subjects can be considered as one activity and the length of this activity equals the total number of weekly hours.

One may want to vary the level of aggregation to simulate higher grades in more detail. In this case activity 1 could be defined as all subjects in primary school; activities 2, 3, 4 etc. could be science, languages, arts, etc. in lower secondary school, and new activity numbers could be used for upper secondary school, a different number for each subject, for instance.

The programme calculates total current costs for the level for each activity. For example, if one wants to know the cost of language education in secondary school this can be obtained by giving the same code number to all corresponding subjects.

Class size

We assume that the pupils normally are kept together in classes and that there is a given average class size which may vary between units. The class size is regulated in many countries by the government. The regulations may be in the form of upper and/or lower limits, and may depend on the size of the school. The effects of such regulations are usually studied and the average class size is calculated. This average class size is an input to the model given as a function of the unit number.

However, in some cases, the class is divided into two or more parts (labs), or two or more classes have some "activity" together (physical education, for instance). There may also be non-compulsory activities for which the class size depends both on the proportion of the class taking this activity and on the extent to which pupils from different classes are taught together. When such special class sizes have to be taken into account for the problem studied, they are used as input to the model for each unit and activity for which they differ from the class size normal for the unit.

Teacher categories

The Resource submodel calculates the required number of teachers of different categories. Any kind of classification principles of interest for teacher demand calculations can be used. The categories in the Teacher Supply submodel are, however, chosen with regard to the background of the teachers and preferably so that data concerning the present stock of teachers are available for each category. Comparisons between supply and demand are therefore facilitated if the same classification principles are used in the Resource submodel as in the Teacher Supply submodel. If different definitions are used in the two submodels, certain "translation" data giving the relationship between the categories have to be read in if the Teacher Comparison submodel is used.

The Resource submodel calculates the teacher demand on the basis of information concerning the intended use of teachers, that is, for each unit and activity, information about the category of teacher needed and corresponding teaching obligations and salary. The salary may vary between different teachers belonging to the same category, if the variation is caused by a difference in subject or unit taught, or a difference in teaching obligations. If the difference in salary is due to a difference in teacher experience, the average salary can be used as input.

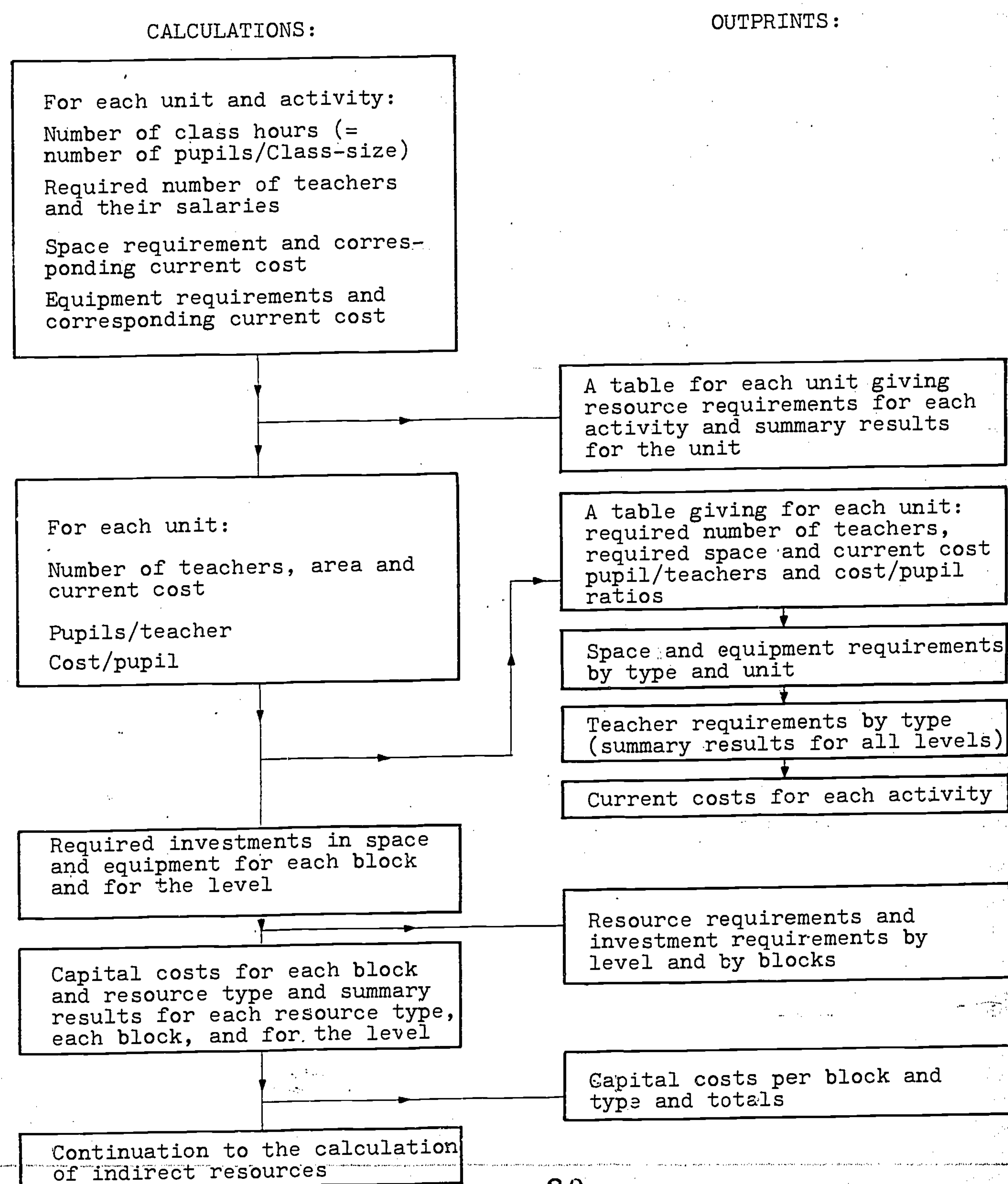
Space and Equipment

Space requirements directly connected to the curriculae consist of class-rooms, gymnasiums, labs., etc. For these direct space requirements code numbers are so defined that equal code numbers imply equal costs per unit of area and equal number of hours of average weekly utilisation. Furthermore, it is assumed that joint use can be made of space of the same type within one level or within various groups or blocks of units within one level. This assumption is the basis for the calculations of investments. The required investment for one specific year is calculated by comparing the total requirements of space type X for one level (or for blocks of units) with a "comparison stock", (for instance, the stock required the previous year or the existing stock) and the increase, if any, is counted as required investment.

The choice of the previous year's requirements as comparison stock has, however, a disadvantage. It may happen that resource requirements after an increase may start decreasing again. In this case one may not want to invest to meet the requirements entirely the peak year but instead seek some temporary solution. To calculate the yearly investment requirements as the difference between the resource requirements of two consecutive years may thus be misleading. The model calculates instead the investment requirements for year T as the increase in the resource requirements from the base year (= the starting year of the simulation) to year T. It would have been preferable to have the actual existing stock in the base year as comparison stock, but such stock data seem rarely to be available. If there is an imbalance the base year the investment calculations of the model have to be adjusted for the existing shortage or surplus.

As examples of Equipment needed directly for the teaching function, teaching aids and school books may be mentioned. Equipment with a comparatively short life-time (school books) is usually counted as current costs while others (TV sets) may be paid out of the capital budget. For the first type of "non-durable" equipment we do not define type or code numbers, but use annual cost per student as input data. This cost may vary between units and activities. "Durable" equipment is described by code numbers unique for each level. These are treated analagously with direct space requirements, i.e. (1) joint use can be made of them, (2) they are characterised by a certain average weekly utilisation time, and (3) a yearly current cost for maintenance per item as well as the investment cost per item are input data.

BLOCK DIAGRAM FOR DIRECT RESOURCES



Calculations

In principle, the following types of calculations are performed in the Resource submodel for each level and each simulation year.

Direct Resources

(i) Physical requirements (teachers, space, equipment) and investments (space, equipment).

(ii) Teacher salaries.

(iii) Current costs.

(iv) Capital costs.

Indirect Resources

(i) Physical resource requirements and investments.

(ii) Current costs.

(iii) Capital costs.

Total direct and indirect area requirements and costs are also calculated.

The computer programme has been so designed that any of the calculations listed above can be excluded when not needed for the problem under consideration.

The block diagram on page 18 for the direct resource part of the Resource submodel outlines the organisation of the calculations and illustrates what types of outprint can be obtained.

A detailed description of the Resource submodel is presented in Appendix 2.

5. Teacher Supply Submodel

Similarly to the Resource Submodel described above, the Teacher Supply submodel is optional in the computation sequence performed by SOM.

The Teacher Supply submodel calculates for each year of the simulation period the supply of teachers of various categories. These categories correspond primarily to the teacher's educational background, i.e. to his competence for teaching in certain grades and subjects.

The calculations are based on the stock of teachers the previous year and changes in this stock due to:

(a) Retirements

(b) Death

(c) Inflow into the teaching profession of graduates from teaching colleges or other parts of the educational system

(d) Inflow from or outflow to other "occupations"

(e) Immigration or Emigration

In addition to the flow categories given above, adjustments can be made for internal changes in the teacher stock due to additional qualifications acquired by certain teachers.

In the Teacher Supply submodel, feasibilities for sensitivity analysis have been built in. This means that, in the same run of the model, the teacher supply can be determined for a number of different values of certain policy variables or parameters.

The calculations performed in the Teacher Supply submodel are based on certain assumptions as to the data availability and the structure of the different in- and out-flows of the teacher stock. These assumptions will be listed below.

Data Availability

For the calculation of both deaths and retirements, knowledge of the age distribution of the teacher stock is necessary. The ideal information should be the knowledge of this age distribution for each category. But even if these distributions are known for the base year of the simulation period, they are very difficult to update for the following years as this would require knowledge about age distribution for all the in and out flows. Consequently, we assume two alternatives for the information available about the age distribution for the base year:

- the distribution can be estimated for each category separately;
- the distribution can only be estimated for the total teacher stock. The model assumes in this case that the same distribution is valid for each category.

Information may either be available for each year of age or only for various age intervals. In both cases we assume that the data are aggregated according to conveniently chosen age intervals before being read in.

The age distributions read in for the base year are not updated endogenously in the model during the course of the simulation as this would require data for the age distributions of all the in and out flows. A change in the age distribution over time, can, however, be read as input if it is estimated exogenously. The use of this feasibility probably improves the general accuracy of the results in only very extreme cases, such as a very sudden increase in the number of young teachers in combination with the use of the model for a long simulation period.

As to the inflow of non-active ex-teachers and people from other activities we only consider the net inflow, i.e. inflow - outflow. There are some different cases as to the data availability.

- If data can be estimated for each category and each year of the simulation period, these data can be used as inputs.

- It may be easier to estimate the inflow as a percentage of the existing stock of teachers the previous year. This set of estimated percentages for each category and each year may be used as inputs.

Net immigration: we assume that these data can be estimated for each category and each year of the simulation period.

Some explanations are given below about the assumptions concerning the inflow of graduates from the educational system and the internal changes in the teacher stock.

Translation Ratios

This concept was introduced for the treatment of the inflow of graduates from the educational system. There is usually not a one-to-one correspondence between the educational output from different units and the teacher categories (for definition see page 19) as the disaggregation used in the Student Flow submodel may be different from the disaggregation of teachers into categories. Different educational units may produce teachers belonging to the same teaching qualification category. There can, however, also be a flow from one educational unit into different teaching categories. This will, for instance, occur when the educational output, as obtained from the Student Flow submodel, is not divided up according to what subject or groups of subjects they have specialised in and when at the same time the teaching categories are defined so that different subject specialisations correspond to different categories. In order to give possibility for the user to trace out the consequences of different policy alternatives, the inflow of teachers coming directly from the educational system is determined by two different rates. The direct input, obtained from the Flow submodel is the stock of each "producing" unit year t-1 (if t is the simulation year). These stocks will be multiplied by the following ratios:

- The ratio of students of unit I who pass an examination corresponding to teaching category Q.
- The ratio of those from unit I who "graduated" in category Q and who choose the teaching profession.

These two ratios are parameters which can be influenced by educational authorities. The second one translates the behaviour of the graduates and is to a fairly large extent determined by labour market conditions. These ratios will be referred to below as the "rate of success" and the "rate of choice".

Internal flows

As mentioned above, teachers with the same formal qualifications are assumed to belong to the same category. Internal flows between different categories can thus occur only when teachers acquire additional theoretical qualifications, for instance by evening or summer courses. If they leave their teaching activities at some time for additional studies, they will be counted (negatively) in the net inflow of ex-teachers. The internal flow not taken into account in this net inflow is thus very small and may be neglected when information is not available. Internal flows are assumed to be estimated in absolute figures and be input data for the model. These adjustments are optional and could be skipped if desired.

Sensitivity Analysis

The inflow from the educational system can simultaneously be computed for different alternatives as to the value of the two ratios described above that translate students into qualification groups. These alternatives will correspond to different policies as to the production of graduates for the teaching profession; these policies will change the "rate of success". Furthermore, the attraction of the teaching profession described with the parameter "rate of choice" can vary within certain limits which translate the uncertainty of the estimation. The combination of these two factors leads to alternative values for the teacher stock which are described in terms of variation around a mean stock value.

A detailed description of the Teacher Supply submodel is presented in appendix 3. A general block diagram for the submodel appears on the following page.

6. Teacher Comparison Submodel

The supply of teachers is calculated in the Teacher Supply submodel and the demand for teachers in the Resource submodel. In the Teacher Comparison submodel the supply and demand are compared for each category of teachers and each level of the educational system; these operations are processed for each year of the simulation period.

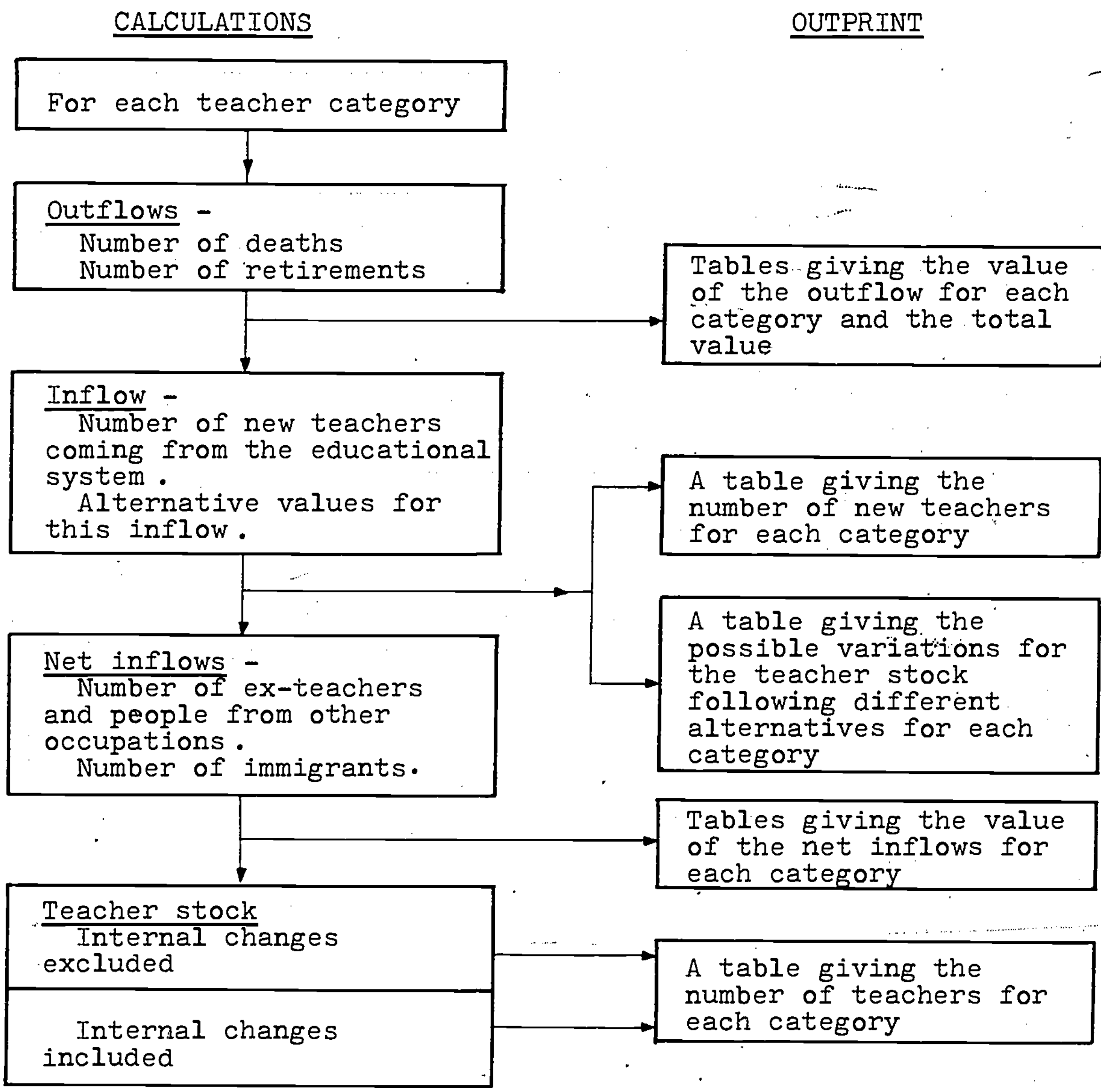
Furthermore, policy alternatives are designed in order to reach a more balanced situation. On the demand side, the influence of certain changes of such policy parameters as class size and teaching obligation on the supply/demand balance is investigated. For each level a sequence of changes in percentage in class size and/or teaching load that correspond to a more balanced situation is produced.

On the supply side, short term adjustments produced by stock alternatives imbedded in the Teacher Supply submodel could be used if necessary.

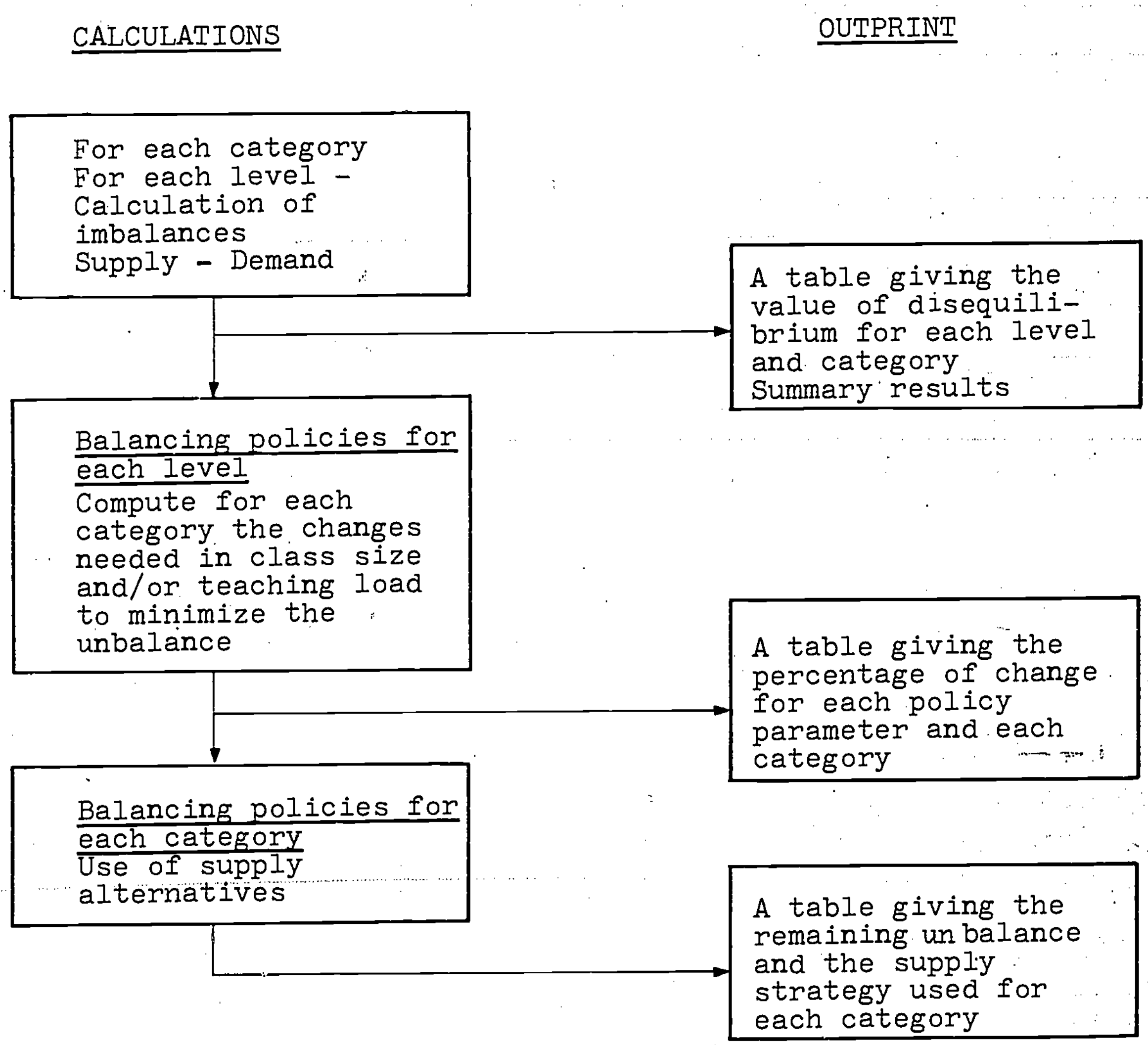
The sequential method used for computing the adjustments of different policy parameters is described in appendix 4.

A block diagram for the Teacher Comparison submodel is presented on page 24. The block diagram on page 25 illustrates the connection of the different submodels.

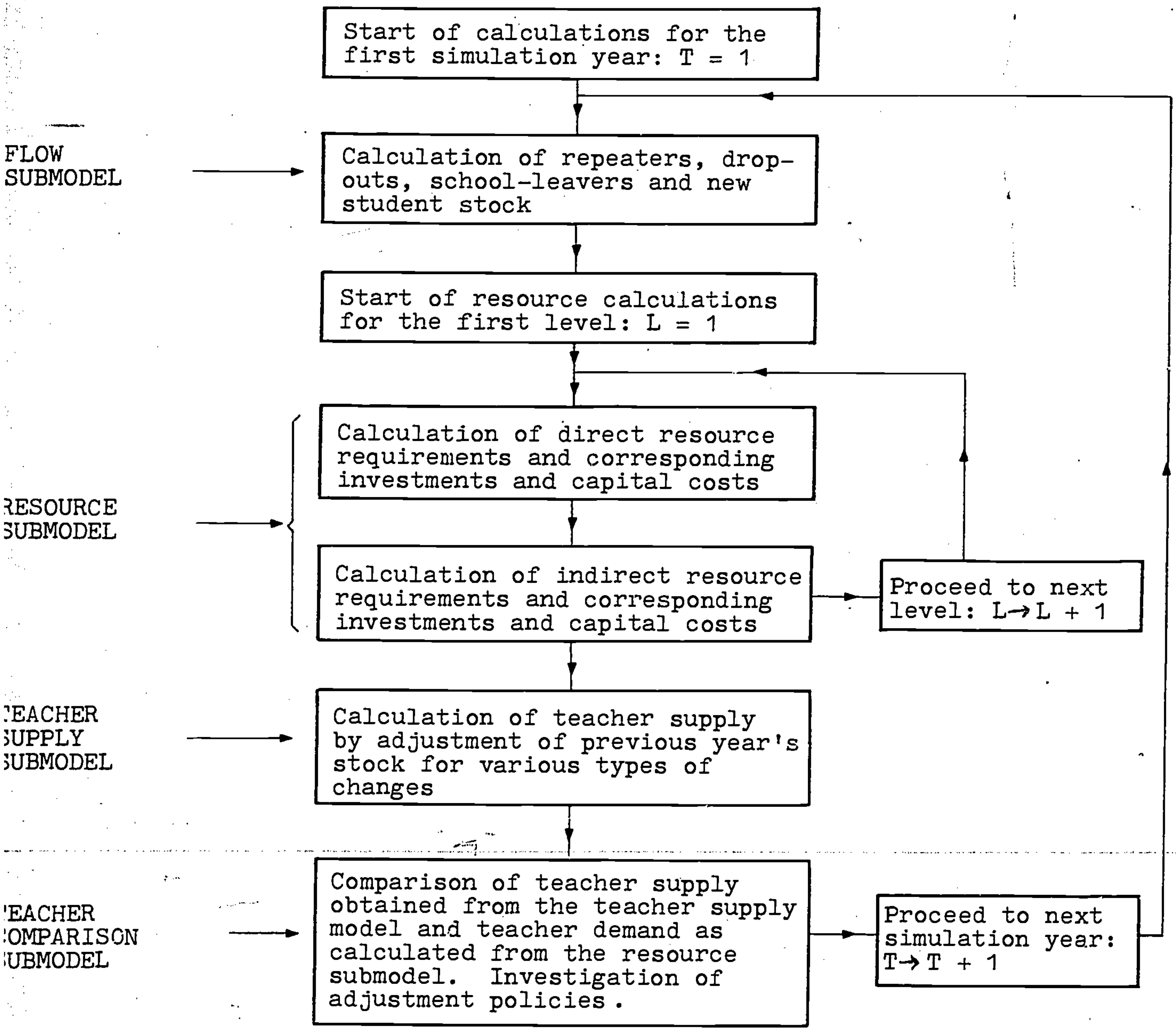
BLOCK DIAGRAM FOR TEACHER SUPPLY



BLOCK DIAGRAM FOR TEACHER COMPARISON



ORGANISATION OF SOM



7. An Application Study

Various fields of application of SOM are apparent from the above description. It can. in principle, be considered as a tool for consequential analysis and used to answer the following types of questions:

What will the consequences be for:

(i) the size of the pupil stock in various parts of the educational system and the production of qualified manpower of various categories;

(ii) the supply and demand for teachers;

(iii) physical and financial requirements;

if the educational system continues to develop according to present trends or if certain reforms are carried out. The effect of the considered reforms on the input data of the model must, naturally, be determined exogenously.

An illustrative example has been chosen to show how a specific problem can be dealt with by the SOM model. It is a British case study related to an increase in compulsory schooling. The raising of school-leaving age from 15 to 16 years is a reform already decided upon. The specific problem we have singled out is the choice of time schedule for the introduction of this reform.

Criterion of Choice

As the reform has been found desirable, there is a general wish to introduce it fairly soon. Considerably more teachers and school buildings will, however, be needed. A smooth change in the requirements of resources should probably be aimed at to ensure a successful implementation of the reform. Such a smooth development may be obtained by fitting the time of the reform to the demographic development and by extending the period of introduction over several years. The smoothest development may, however, correspond to a very slow introduction rate, which may not be in line with the original intentions. A criterion of choice expressed only in terms of "smoothness" may, therefore, be unsuitable. We have examined the resource requirements for a number of policy alternatives, all of which imply that the introduction of the reform would be completed in 1974 or earlier. Without defining a precise criterion, the "best" policy cannot be uniquely determined. The choice of policy will be a matter of judgement for which the present study should provide some relevant information. The reliability of the results will be discussed in the final paragraph.

Policy Alternatives

Three different starting years for the reform have been examined, namely 1970 (= alt. 2), 1971 (= alt. 3), and 1972 (= alt. 4). These alternatives have been combined with three cases concerning the introduction rate:

A. direct rise from 15 to 16;

B. rise made in half-year steps during two consecutive years;

C. rise made in steps of 4 months during three consecutive years.

The model has been used to estimate the consequences, such as the number of teachers and building space required for the nine policy alternatives (2A, 2B, 2C, 3A, 3B, 3C, 4A, 4B, 4C) defined above, as well as for a comparison with the alternative (= alt. 1) which involves no increase in compulsory schooling.

Input data considerations, the method of applying the model, and calculated results are presented in appendix 5. Here we shall outline the general procedure and present the main results.

Application of the Model

The increase in the number of school children aged more than 15 years will affect the number of graduate and non-graduate teachers required. As the same categories of teachers also teach in primary school, both primary and secondary schools have to be included in the simulation in order to estimate the number of teachers required in the various alternatives. Other parts of the education system, such as universities, teacher-training colleges, further education, special institutions (for instance for handicapped children), and nursery schools have been excluded in this application of the model, as they do not directly influence the two main factors under study, i.e. the increase in teacher and space requirements caused by the reform. If we had wanted to use the model to estimate future supply of teachers we would, of course, also have had to include universities and teacher-training colleges in the simulation. It is, however, probably easier to make supply meet demand in alternatives that correspond to a smooth increase in demand. We have, therefore, limited this study to include estimates on the demand side only. Consequently, we have used only two submodels, the Flow submodel and the Resource submodel, and excluded the other two submodels, the Teacher Supply and the Teacher Comparison submodels. The fact that the parameters we want to study are connected with only a part of the educational system does not mean that all other parts will be untouched by the reform. As the main increase of pupils will be in modern secondary schools, there will probably be an increased demand for places in further education. To adapt the further education system to the reform may require a number of changes in curricula, acceptance rules, number of places supplied, etc. We have excluded these problems from our study, as they do not seem to affect the appropriate time and method for implementing the reform.

Input Data

Primary school has been treated as one "level" and divided into "units", different grades corresponding to different units. Secondary school has been divided into two "levels" in such a way that the lower level is unaffected by the reforms. A distinction has been made between different types of schools and different "branches", such as modern schools, grammar schools, etc. Input data to the Flow submodel and the Resource submodel have been obtained from available statistics as described in appendix 5. The following assumptions have been made:-

(i) the present trends in the transition coefficients will continue;

(ii) the present distribution between graduate and non-graduate teachers in each unit remains unchanged;

(iii) the present pupil/teacher ratio remains unchanged in each unit;

(iv) required space investment for each additional pupil equals the present minimum requirement figure;

(v) when the school-leaving age is raised, a number of pupils will be "forced" to continue in school for one more year. We distinguish between two alternatives as to their possible behaviour: those who are "forced" to continue for one more year (1) leave school as soon as possible; or (2) adopt the continuation pattern of those who continue voluntarily.

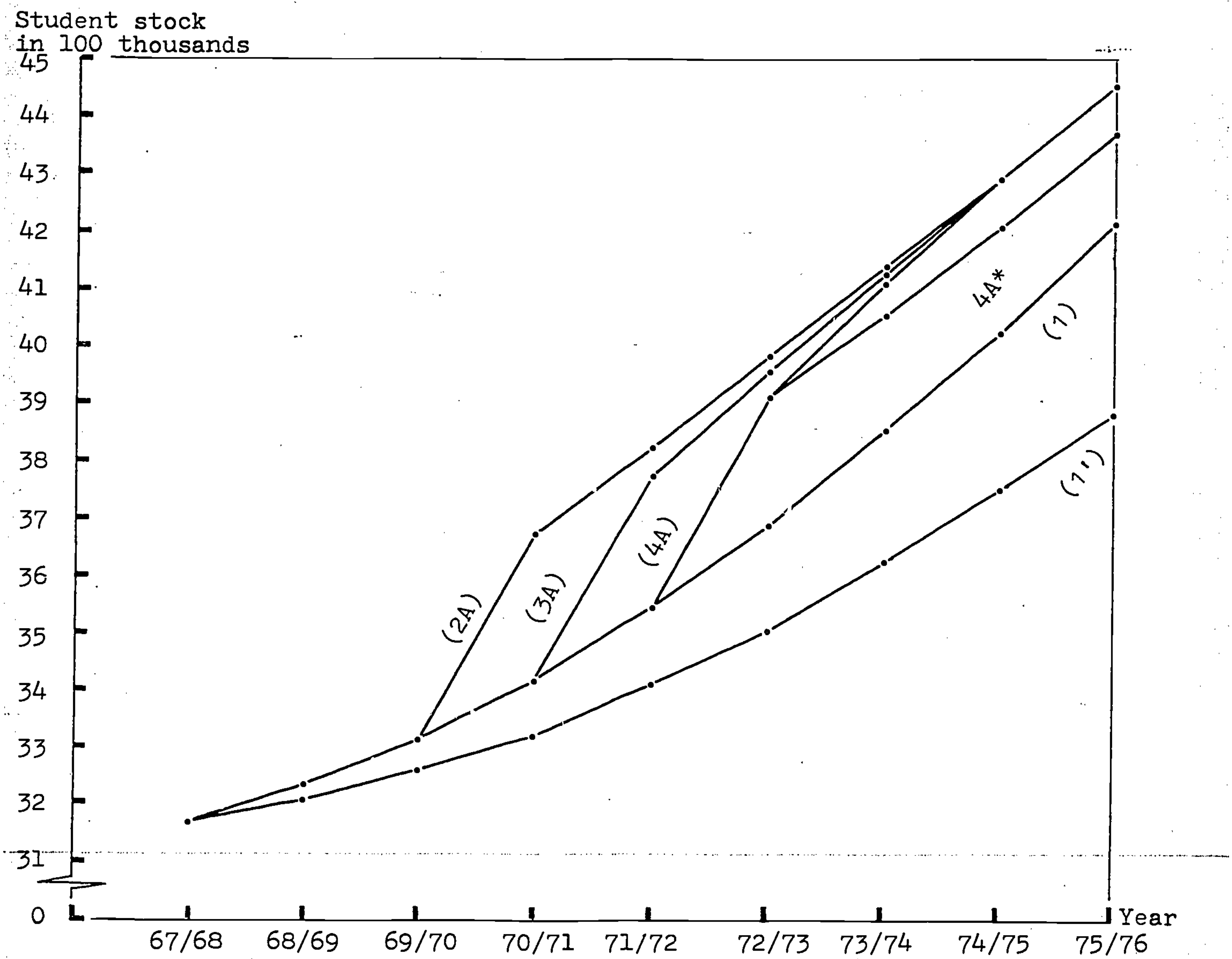
The last alternative has been combined with all the policy alternatives mentioned above. The first alternative has been combined with 4A and denoted 4A*.

Calculated Quantities

The computer programme has been run for each policy alternative, and pupil stocks and teacher and space requirements calculated for each year of the simulation period up to 1975/1976.

The future numbers of pupils are obtained for each year and for each unit and level, (cf. appendix 5). The results for secondary school are illustrated in graph 1 for alternatives 1, 2A, 3A, 4A and 4A*. The dotted line 1' corresponds to alternative 1 (no increase in compulsory schooling), but is calculated for constant transition coefficients.

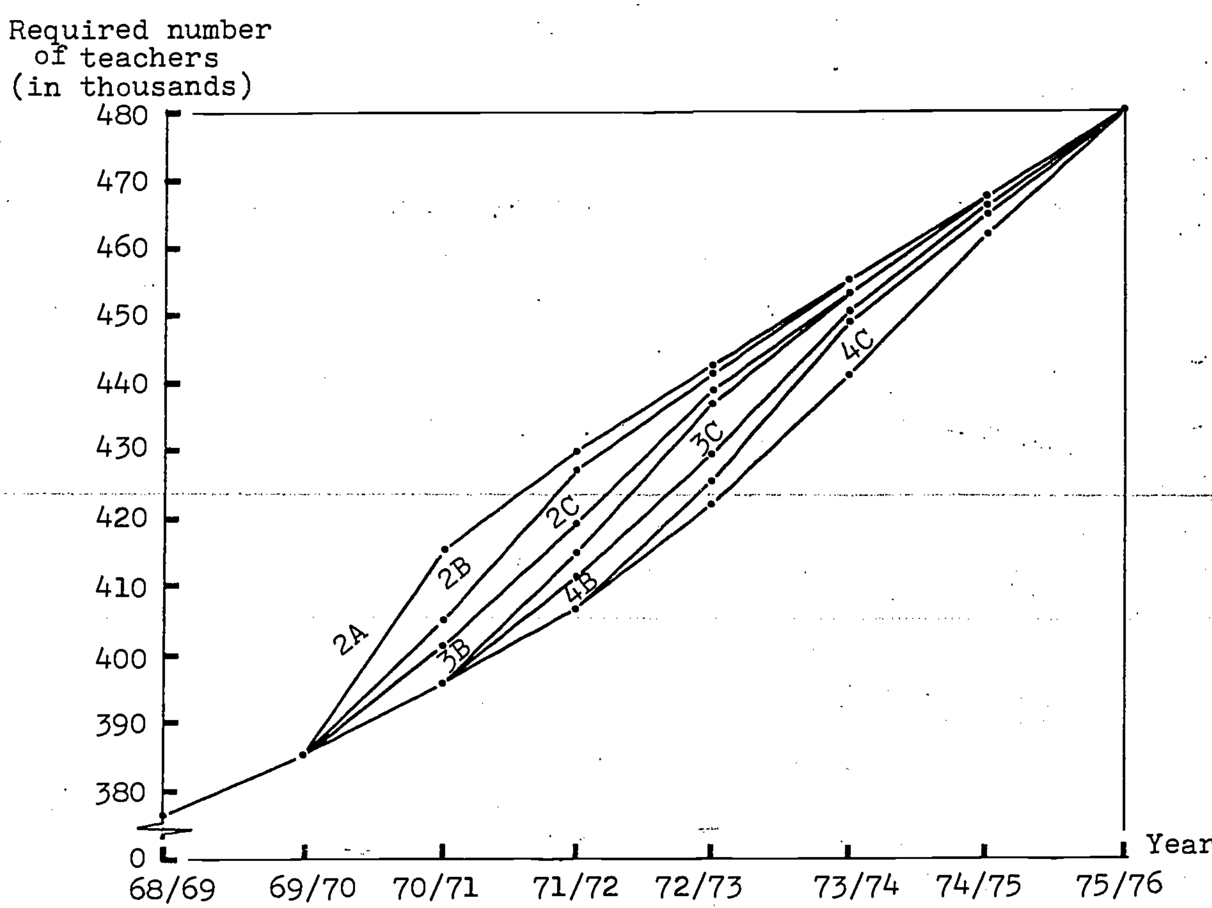
Graph 1: Development of student stocks in secondary school according to the alternatives 1, 1', 2A, 3A, 4A and 4A*.



From the line corresponding to alt.1., i.e. no increase in compulsory school age, it can be seen that there will be a steady and growing increase in the number of secondary school pupils despite the demographic development with a decreasing number of 16 year old children in the beginning of the seventies. This is due to the increase in the number of younger secondary school children together with the growing tendency to stay on in school (if present trends continue). The student stock curves thus indicate that it is already somewhat late to fit the reform to the demographic development.

The calculated required number of teachers in primary and secondary school is illustrated in graph 2.

Graph 2



As could have been expected, the slower the introduction rate the lower the yearly increases. The policy alternatives 2C, 3C and 4C, i.e. a 3-step introduction rate, all give yearly increases between 4% and 5% during the reform period. The increase in space requirements has been calculated for each school level and each policy alternative. The difference between the different alternatives is of the same kind as for teacher requirements (cf. appendix 5).

Conclusions:

To see what conclusions can be drawn, we shall first examine how the calculated results are affected by the various assumptions we have made (cf. p.27).

We assumed that present trends in the transition coefficients, i.e. the tendency towards staying on longer at school, would continue. If this tendency suddenly disappeared altogether, the future number of pupils would noticeably diminish as illustrated above by the difference between alternatives 1 and 1'. As to the pupils' reaction towards the reform, we assumed, except in the comparison case 4A*, that those who were "forced" by the reform to stay on continued voluntarily to the same extent as those who continued before the reform. Here we may have over-estimated the tendency to stay on. On the other hand, certain pupils who earlier stayed on after the age of 15 may stay on even longer because of the reform, in order to keep their "educational differential".

In short, the calculated values for future school populations may be over or under-estimated (probably somewhat overestimated), depending on the pupils' reaction towards the reform. Even in the cases (1' and 4A*) where a lower tendency to stay on at school is assumed, there will nonetheless be a steady increase in the school population. As this increase is the basic feature for the differences between the examined policy alternatives, the uncertainties in the estimated values are without interest for our particular problem.

The calculated resource requirements assume unchanged pupil/teacher ratios. Here it should be noted that data concerning the present ratios are somewhat contradictory. If teacher requirements are estimated on the basis of available data (cf. appendix 5) on pupil numbers, class size, periods per week and weekly teaching obligations, the figure obtained for secondary school teachers is 40% higher than the present stock. This may be due to the number of supervised periods a week being considerably lower in practice than the "theoretical" figure (30 to 37.5 periods). Alternatively, there may be some general incompatibility in the conditions for the collection of the different sets of data. For all computer calculations, input data have been so adjusted that they correspond to the pupil/teacher ratio which is obtained for the present number of teachers and pupils. If there is a "hidden" teacher shortage at present, this shortage has thus been projected into the future. This means that there might be a general downward bias in the estimates of future teacher requirements, but this bias would not affect the characteristics of the differences in teacher requirements as between the different policy alternatives.

Class sizes have been assumed unchanged by the reform. Present average class-size values for children above 15 are, however, surprisingly small (9-18). It seems as though different classes are not put together, even when the class-size diminishes considerably. The small average class-size values seem thus to indicate that resources are at present under-utilised. As this under-utilisation will diminish automatically with increasing school-leaving age, the calculated increase in resource requirements, caused by the reform may thus be too high. This does not, however, affect the differences between the "smoothness" of the investigated policy alternatives.

As the various uncertainties in the calculated results do not affect the principal differences between the investigated policy alternatives, we can base our conclusions directly on the calculated results. In spite of the present decrease in the numbers of certain age groups in secondary school, the increased population in primary school and the tendency to stay on longer at school cause a yearly increase in the primary and secondary school population of about 2.5% and a somewhat larger increase of 2.5% to 3% in required resources. If high increases in resource requirements are to be avoided, the introduction should be spread over several years. A one-step increase in compulsory schooling from 15 to 16 years is likely to cause implementation difficulties, as it would mean a sudden increase of about 6 to 8% in resource requirements, more than twice the normal yearly increase. There seems to be no reason to spread the increase in school-leaving age over more than three steps, as these would be enough to bring the yearly change in line with changes which might occur in any case during the seventies, irrespective of the reform, because of the increasing school population.

As to the starting year of the reform, alternative 2C (i.e. start in 1970) is slightly, but not significantly, "smoother" than 3C and 4C (start in 1971 and 1972 respectively). There is thus no reason to postpone the start in the hope of more favourable demographic conditions later on. A reason to postpone the reform could be that more preparation time was needed, but as the reform was decided on several years ago this is probably not the case. To start introducing the reform soon, but at a slow pace, seems to be the preferable alternative.

Appendix 1

FLOW SUBMODEL

The Flow Submodel calculates for each year t of the simulated period the new stock of students or pupils in each unit and the outflow from the educational system.

The students may be divided up according to sex and/or socio-economic background. The number of different such groups is denoted NSG* (NSG≤4 in the present version of the computer programme).

The computer subprogramme Flow carries out the calculations for each simulation year. The calculations are based on the following main categories of input data:

(i) Demographic and school-entry data.

(ii) Student stock in the base year (year 0). The stock NN(i,k,ℓ)* is given for each level ℓ, each unit i, and each student group k.

(iii) Transition coefficients for each level and unit (and student group). These coefficients may change over time.

(iv) Restricted entry data. For each level input information is needed about which units are restricted and the number of places supplied in each of them. This number may vary over time.

In addition, certain structural data are needed, some of which are also used in other parts of the programme. The structural input data are defined below:

NMLF: Number of levels for which student stocks and flows are calculated. (NMLF≤5).

NU: NU(ℓ) is the number of units in level ℓ.

NUF: NUF(ℓ) is the number of units which belong both to level ℓ and the preceding level. These units are given the lowest numbers in level ℓ and the highest numbers in level ℓ-1. When summary results are calculated for the level they are counted to the lower level. In principle, they consist of the units in the lower level from which there is a flow of students to the higher level.

NR: NR(ℓ) is the number of restricted units in level ℓ. (They are not necessarily restricted during the entire simulation period).

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* Block letters are used in all the appendices for quantities which are input data to the computer programme.

NNCOEF: A student stock coefficient. NN(i,k,ℓ) that is the number of students in unit i, level ℓ, that belong to student group k must never exceed 20,000, because of limited computer memory space. (Only a half-word has been used for NN). NN is usually below this limit in small countries, particularly if the school system has been divided up in many units. If NN exceeds the limit in the base year or if NN can be expected to surpass the limit during the course of the simulation, all student stock input data as well as input data for the demographic forecasts and the number of supplied places in the restricted units should be reduced by a factor NNCOEF before they are read in. NNCOEF may, for instance, be chosen equal to 10, 100 or 1,000.

The following main type of calculations are carried out in the Flow submodel each simulation year:

a) New enrolments
b) Transition coefficients for the year in question
c) Repeaters, drop-outs and school leavers
d) New student stock
e) Redistribution because of restricted entry

a) New enrolments

The number of new enrolments from outside the educational system is calculated from demographic forecasts and school -entry data. We have assumed that there are only such new enrolments into Level 1. The units receiving these new enrolments are given the lowest numbers. The number of such units is NUF(1). (NUF(1) is thus defined in a slightly different way from NUF(ℓ) for $\ell > 1$, see definition above). The demographic data are expressed as the estimated number of children (= *child*) of school entry age for each simulation year. If all children enter at the same age (= NAGEL), CHILD(t) denotes the number of children aged NAGEL in the simulation year t. If the school entry age covers several age groups this can also be taken into account. Input data are then the proportion (=F) of children of each possible school entry age who enrol. The precise definitions of the demographic and school entry inputs are given below:

NAGEL: The lowest age at which children enrol in the simulated system.

NAGEH: The highest age at which children enrol in the simulated system.

F: F(1) is the proportion of children aged NAGEL that enrol at this age. The general definition of F(y) is the proportion of the age group NAGEL + y - 1 that enrol.

CHILD: Demographic forecasts for the number of children aged NAGEL (lowest school entry age). CHILD (t) is the number of children aged NAGEL in the year that corresponds to the simulation year t + (NAGEL - NAGEH).

(If NAGEH NAGEL, say NAGEH = 7 and NAGEL = 5, input data concerning the number of 5 year old children are thus also needed for the years before the simulation period. This is simply due to the fact that the number of children aged 7 at the start of the simulation is calculated in the model on the basis of the number of 5 year old children two years earlier).

<u>S:</u> $S(i,k)$ is the proportion of those who enrol that belong to socio-economic group k (k = 1,NSG) and enrol in unit i (i = 1,NUF(1)). (The pupils are assumed to belong to the same k-group throughout the simulation).

The calculations are carried out in two steps. The total number of first enrolments each year is first calculated from the demographic data CHILD and the school entry data F. These enrolments are then distributed between the entry units by multiplication by S.

In practice it may, of course, also happen that levels other than the first one receive new enrolments from outside the educational system. These consist either of immigrants or students who restart their studies after having left the educational system a year or more earlier. This can be taken into account in the model by the use of <u>fictitious units</u>, that is, units without any resources requirements, but associated with stocks and transition coefficients.

b) <u>Transition coefficients</u>

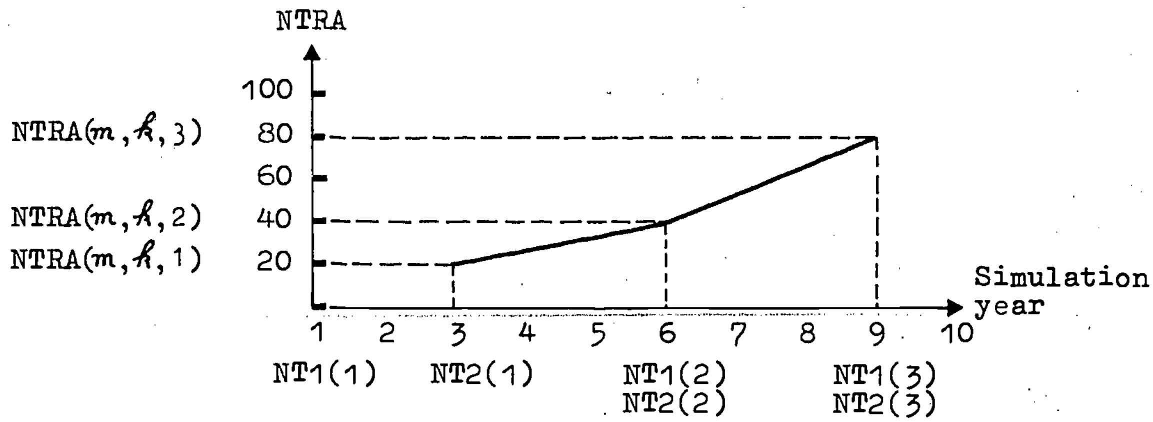
The transition coefficients NTRA (m,k,mp) associated with unit are defined as the ratios of the pupils in who go to various other units NJ(m), repeat, dropout or leave school. The following code notations have been used:

$j = i$	repeaters
$j = 0$	dropouts
$j = 99$	school-leavers

The number of transition coefficients different from 0 is denoted MAXJ. For example, MAXJ equals 5 for unit 2 if there are pupils who continue from unit 2 to unit 3 and to unit 4 and if there are pupils who repeat unit 2, dropout from unit 2 as well as pupils who leave school after having completed unit 2.

If one has distinguished between several (socio-economic) groups k, transition coefficients have to be read in for each group.

If the coefficients are not constant for the entire simulation period, they are assumed to vary over time as a linear function or a function consisting of linear segments. An example of such a function is illustrated overleaf.



By representing the transition coefficient by this kind of function the number of required input data is considerably reduced. Only coefficients corresponding to turning points of the function or to intervals where the function is constant, are inputs (20, 40 and 80 in the diagram). Intermediate values are calculated in the programme by linear interpolation.

The transition coefficient for year   corresponds to the flow between year   - 1 and . For each turning point or constant interval the first year (=NT1) and the last year (=NT2) that the transition coefficient takes on, the constant or the turning point value is read as input. If it is a real turning point, such as for year 6 and 9 in the figure above, NT1 thus equals NT2. If the flow is from unit 2 to unit 3 and if k (= student group) equals 1, we have the following inputs for the example given above.

I = 2   NJ(1) = 3   MAXP = 3

NTRA(1,1,1) = 20	NT1(1) = 1	NT2(1) = 3
NTRA(1,1,2) = 40	NT1(2) = 6	NT2(2) = 6
NTRA(1,1,3) = 80	NT1(3) = 9	NT2(3) = 9

MAXP denotes the total number of different coefficient values needed to describe the coefficient function.

As the transition coefficient values are not read in separately for each simulation year, they have to be calculated when needed. The first main operation for each simulation year and for each level is, therefore, to calculate for each unit and for the year in question the transition coefficients on the basis of the input data describing the coefficients as a function of time. First one checks if the year corresponds to a turning point or constant interval: if this is the case the coefficient is obtained directly from the inputs. Otherwise the end points of the linear segment to which the year belongs are determined and the coefficient obtained by linear interpolation.

The calculated coefficients may be printed out. If MPRINT(5) is put equal to 1 the transition coefficients for the flow between the units are printed out. Correspondingly, the coefficients for repeaters, dropouts and school-leavers are printed out if MPRINT(6) is put equal to 1.

c) <u>Repeaters, dropouts and school-leavers</u>

The development of the educational system is simulated stepwise from year to year. On the basis of student stock data for the base year (= year 0) the number of dropouts during or at the end of year 0 and the school leavers at the end of year 0 is calculated by multiplying the student stock for each unit and k group by the corresponding transition coefficients. The number of repeaters is calculated analogously. The new student stock year 1 is calculated for each unit as the sum of the repeaters in the unit and the flows from other units as described in section d) below. The dropouts during or at the end of year 1 can then be obtained by multiplying the calculated stock for year 1 by the corresponding transition coefficients. These coefficients may differ from those used for the base year as explained in section b) above. The same procedure for the calculation of dropouts and school-leavers is used for each simulation year.

Sums for the different k groups for each unit and for the entire level are calculated. They can be printed out by use of the printing vector MPRINT. MPRINT(1) refers to dropouts and MPRINT(2) to school-leavers. There are the following choices:

MPRINT(I) = 0 No outprints.

MPRINT(I) = 1 For each year and level a table is printed out containing data for each unit and group and summary results for each unit and for the entire level.

MPRINT(I) = 2 For each level and year a table is printed out containing data for each unit and the sum for the level.

The table for school leavers for a certain level ℓ may give incorrect values for the highest units, that is the units from which there is a flow to level $\ell + 1$ when one or more of the units in level $\ell + 1$ that receive this flow are restricted. This occurs when there are students who would have continued to a restricted unit in level $\ell + 1$ were there more places but who leave school if they are not accepted in the restricted unit. The "redistribution" of students who are not accepted in the restricted units is carried out when level $\ell + 1$ contains also the units in common with level ℓ and gives thus the correct number of school-leavers for these units.

d) <u>New student stock</u>

In most cases the new stock in a unit year t is obtained as the sum of the number of repeaters and the flows from other units in the same level. There are, however, some special cases:

(i) For Level 1 the stocks of the entry units are obtained as the sum of repeaters, flows from other units and new enrolments.

(ii) For Levels ℓ (ℓ>1) the units have been so numbered that the lowest numbers correspond to units which belong to the preceding level ℓ - 1 and from which there is a flow to level ℓ. For these units the stock year t was already calculated when the Level ℓ - 1 was dealt with. The stock values obtained earlier are directly transferred to the corresponding units in Level ℓ.

(iii) In the case of restricted entry the new stock, obtained as the sum of flows from other units and repeaters, may differ from the number of available places. In this case the stock value is corrected and the students are "redistributed" according to the principles outlined in section e) below.

The outprint of student stock data is determined by MPRINT(3) the definition of which is analogous to MPRINT(2) and MPRINT(1). MPRINT(3) is thus put equal to 0 if no outprints are wanted, MPRINT(3) = 1 if stock data should be printed out for each unit and each student group, and MPRINT(3) = 2 if separate results for the different k groups are not wanted.

e) Redistribution in case of restricted entry

Restriction of the supply of places usually affects the flow through the system in quite a complex way as there is an interaction between many different factors, such as:

(i) admittance principles;

(ii) distribution of students' priorities and qualifications and interrelationships between these factors;

(iii) supply of places in the restricted units;

(iv) number of students in the "source" units, i.e. the units from which there is a flow to restricted units.

Information on (i) and (ii) is usually incomplete and not available in a form applicable for prediction purposes. There are computer programmes which distribute the available places in restricted entry units between the applicants but such programmes require a given population of applicants, with given qualifications and priorities as input. To use such a programme for prediction purposes a "pre-programme" has to be added which generates a population of applicants with individual characteristics. However, we would still not get any information about the future path of the students not admitted to any of the restricted units to which they have applied. And this is exactly the information needed for our purposes. We are not interested in the paths of the individual students but need a general method for estimating how the students, who do not go to restricted units, are distributed between the other choices open to them, that is between various open units and school-leavers. This distribution, that is the numbers of students who leave school or go to the various open units, will, of course, remain constant over time, if all the four factors mentioned above remain unchanged. We want, however, to simulate the development of the system for the case when there are changes in the number of students in the source units and/or in the number of available places in the restricted units. The simulation method we have chosen assumes information to be available about the "observed" transition coefficients for the base year or a previous year. These coefficients do not give any direct information about the real demand for places, but they are a combined result of the present relationships between admittance principles and students' qualifications and between supply and demand.

The following assumptions have been made:

a) The supply of places in the restricted units is so small in comparison with the demand for places from eligible students that the places will always be filled. (If this is not the case we cease to call them restricted units).

b) If the flow from a source unit j only goes to restricted units those who are not accepted are assumed to leave school.

c) Those who are not allowed to any restricted units choose an "open" unit if there is a flow from the source unit to an open unit.

d) If there is a flow from unit j to several "open" units, those who are not admitted to restricted units are distributed between the open units in proportion to the original transition coefficients.

e) The allocation of the restricted places between students from competing units is proportional to the original flow.

The method for distributing the students from the source units in accordance with the assumptions above is first outlined below for the less complicated case when all restricted units have become more restricted than they were in the base year, that is the admitted students have as high, or higher, qualifications.

First the new stock in all the units of level ℓ is calculated as if no units were restricted, that is in the way described above (section a) - d)).

For each restricted unit the preliminary stock values are corrected as follows:

1) The stock value v in the restricted unit, earlier calculated as equal to the "demand" as described in section d), is now put equal to s, the supply of places in this unit. The "over-demand" $v-s$ is put back to the various source units in proportion to

the original flow.

2) For each source unit j the excess number of students ($=Od(k)$, is the student group), is redistributed in accordance with (b), (c) and (d) above, that is for each k group one proceeds as follows:

3) If there is a flow of k students from j to any open units, $Od(k)$ is distributed between them in proportion to the original transition coefficients for the k group in question.

4) If there is no flow of k students from j to open units $Od(k)$ is added to the number of school leavers from j.

If we now look at the case when a restricted unit has become less restricted, we see that the redistribution procedure outlined above can be followed, the only difference being that $v-s$ and $Od(k)$ now take on negative values. The interpretation of this procedure is that there has been a relative increase in the number of places supplied in the restricted unit. This causes a larger percentage of the students than in the base year to go to the restricted unit and there is a corresponding decrease in the percentages of the students from the source units who go to open units or leave school.

The outprint of the student stock data (see section d)) gives the data obtained after the redistribution procedure outlined above has been carried through. If one wants to know the stock values obtained in the restricted units before the redistribution, one can put MPRINT(7) = 1. For each restricted unit a line is then printed out giving the number of the unit, the preliminary stock and the number of supplied places.

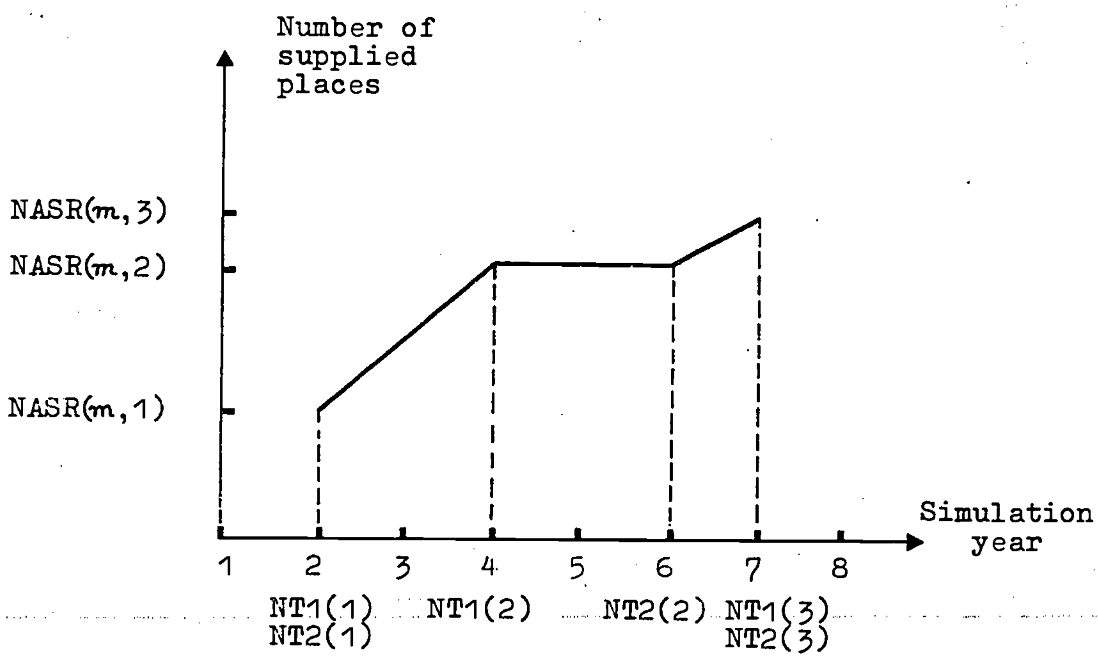
The number of supplied places in the restricted units is not directly given as input for each simulation year. Instead the number is given as a function of time in a similar way as for the transition coefficients. The inputs required for each restricted unit are listed below:

IR(m) number of the m:th restricted unit

MAXP number of different points needed to describe the number of supplied places as a function of time.

NASR NASR(m,mp) is the number of supplied places in the m:th restricted unit, mp corresponding to different points on the curve, see diagram following.

NT1, NT2 NT1(mp) is the left and NT2(mp) the right end of the time interval in which the number of supplied places equals NASR (m,mp) see diagram following.



The restricted unit may be unrestricted in the beginning or towards the end of the simulation. No data are read in for the years during which it is unrestricted. Thus, if NT1(1)>1, this means that the unit is unrestricted for years t for which $1 \leq t <$ NT1(1) Correspondingly, for years $t >$ NT2(MAXP).

There are several reasons why the number of supplied places has been represented by a function in the way described above. In principle, the idea has been:

(i) to keep the number of required inputs down for the simple and most usual cases, that is when the function is constant or linear;

(ii) to be able to deal with more complicated cases, that is irregular functions and restricted units that are restricted only part of the time;

(iii) to facilitate the preparation of input data by leaving it to the computer to carry out linear interpolation in intervals in which the change is linear.

Organisation of the Calculations

All input data are read in the main programme (and stored or put on disk). The following types of calculations are carried out before the Flow subprogramme is entered:

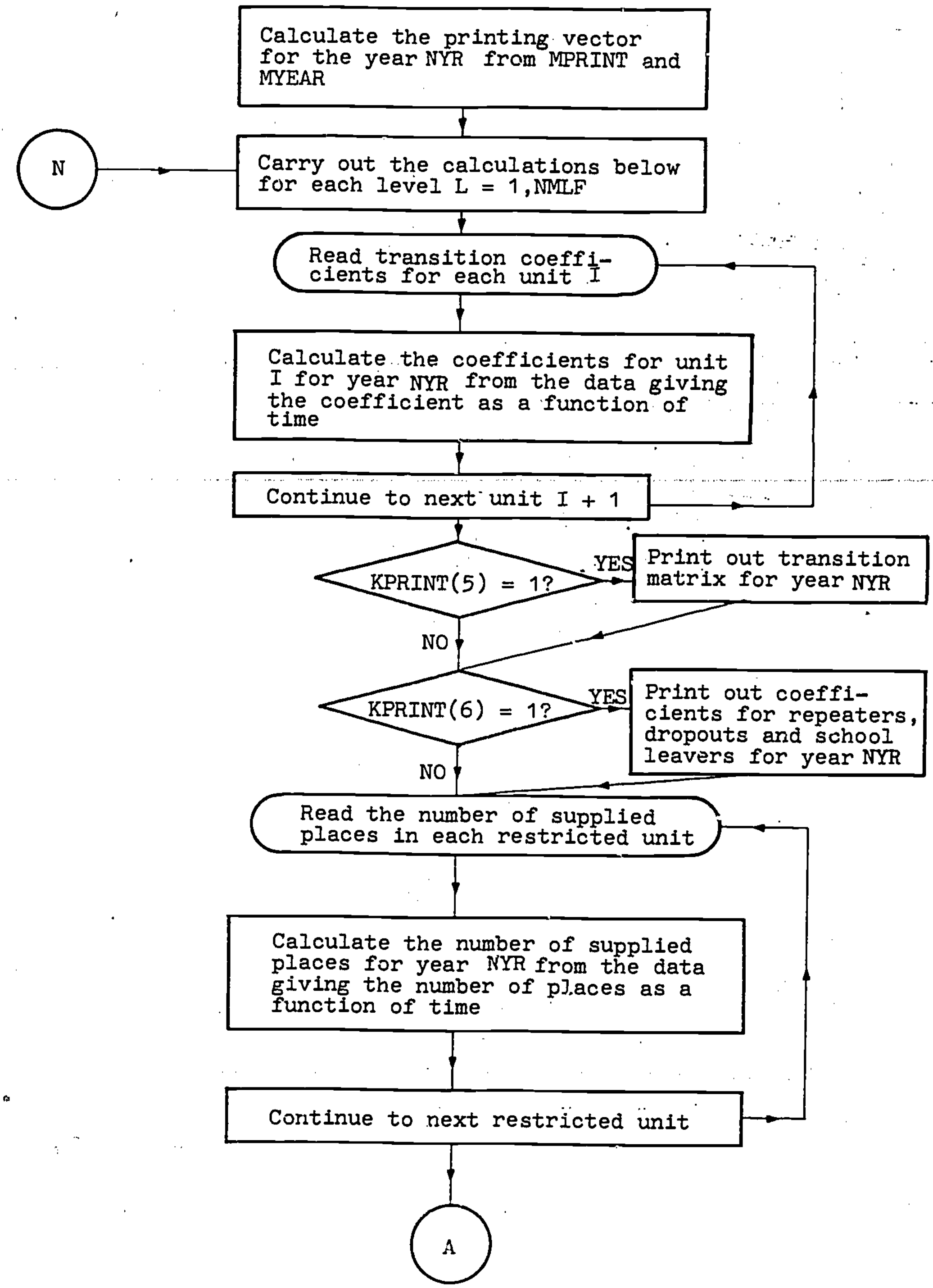
(i) Calculation of the number of first enrolments in the first level for each one of the simulated years.

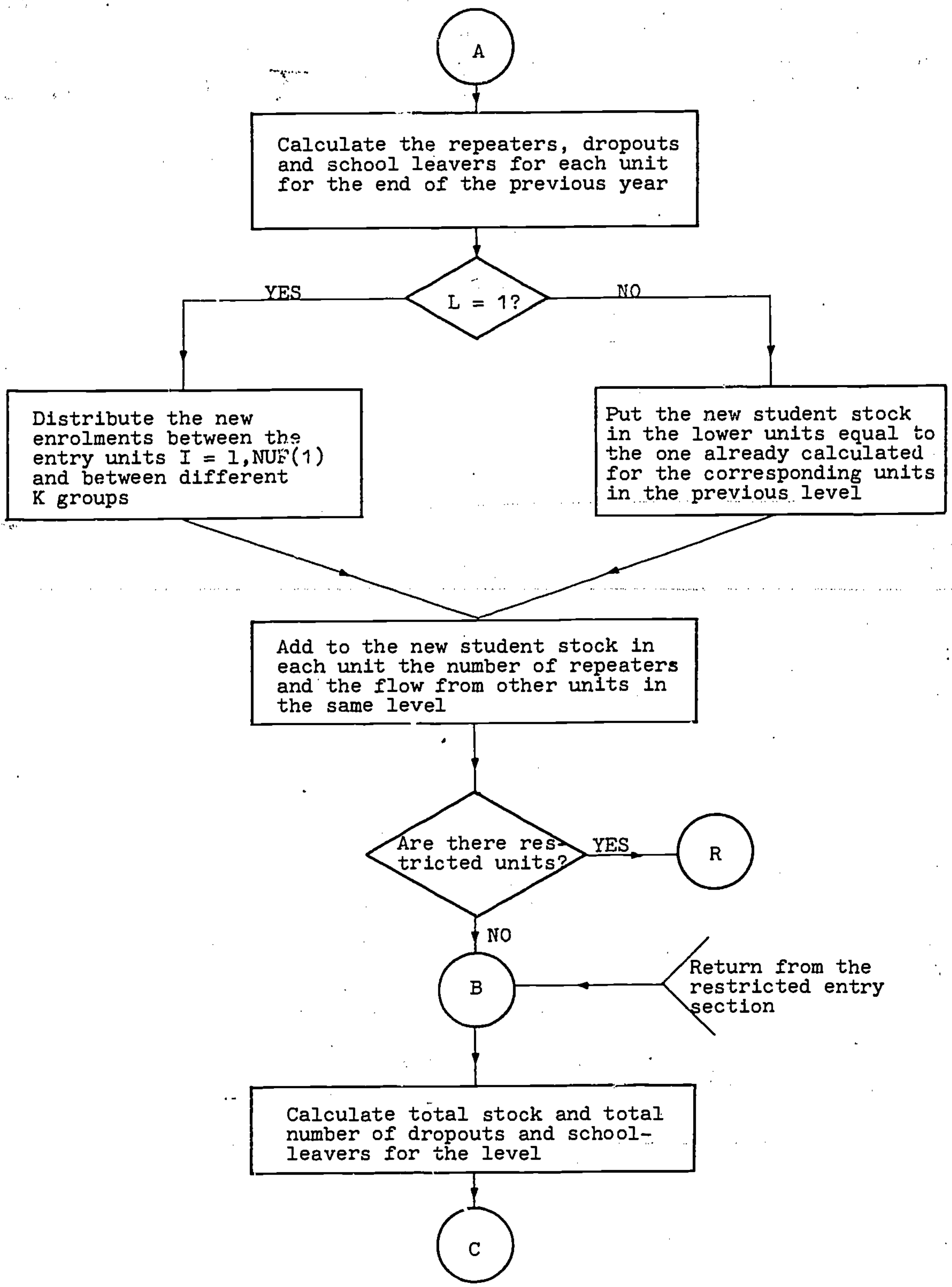
(ii) Summary stock data are calculated for each unit on the basis of the student stock data read in for the base year for each unit and *k* group.

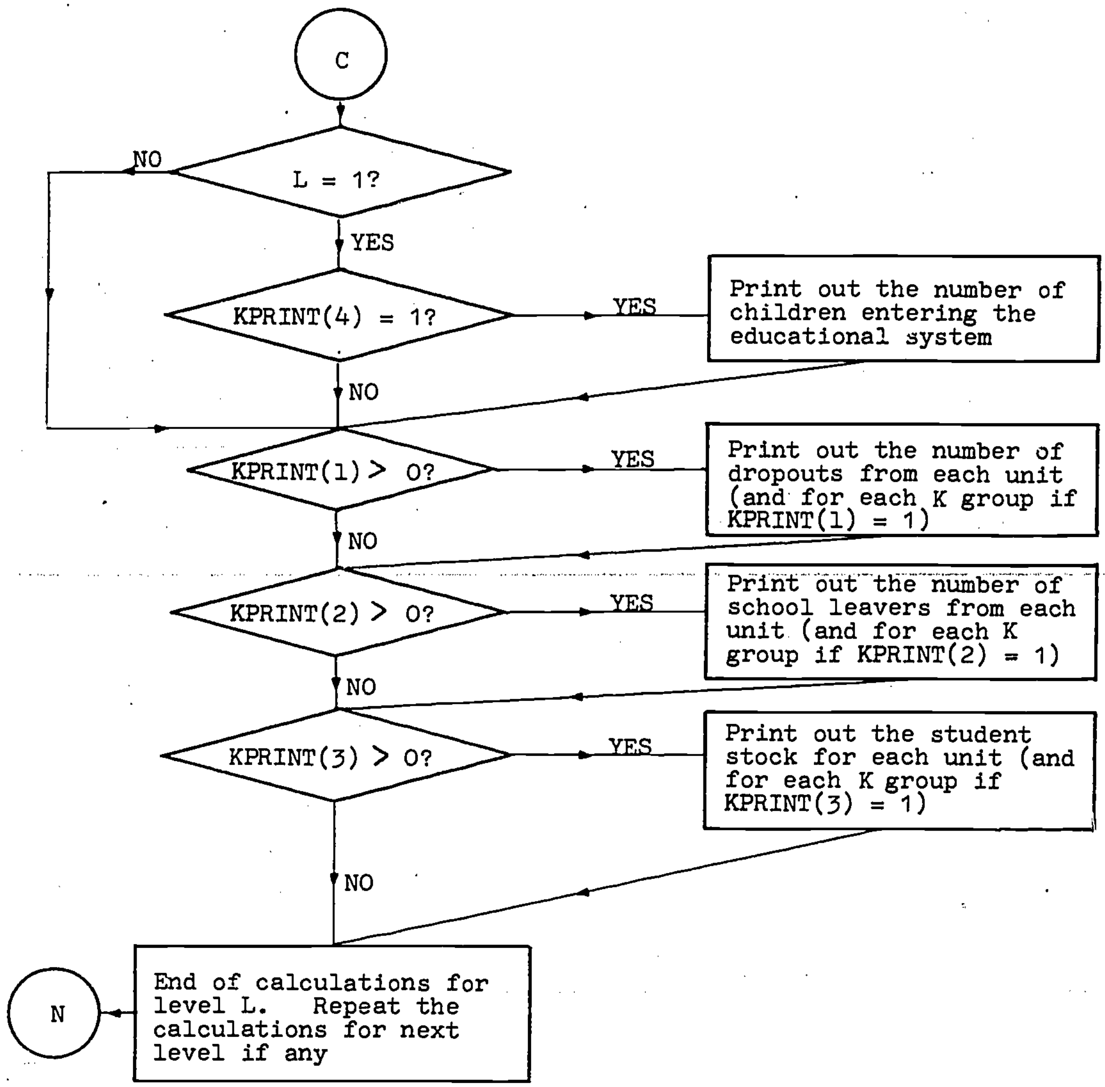
(iii) Tests of input data for consistency. Such tests are carried out for the transition coefficients and for the number of supplied places in restricted units. The programme checks, for instance, if the different time intervals for the transition coefficients are given in the correct order and if certain inputs are within the dimension limitations of the programme.

The calculations carried out in the Flow subprogramme for each simulation year NYR (NYR = 1, NYRS) are outlined in the flow chart on pages 43 to 47. A more detailed description of the computer programme is given in Part II.

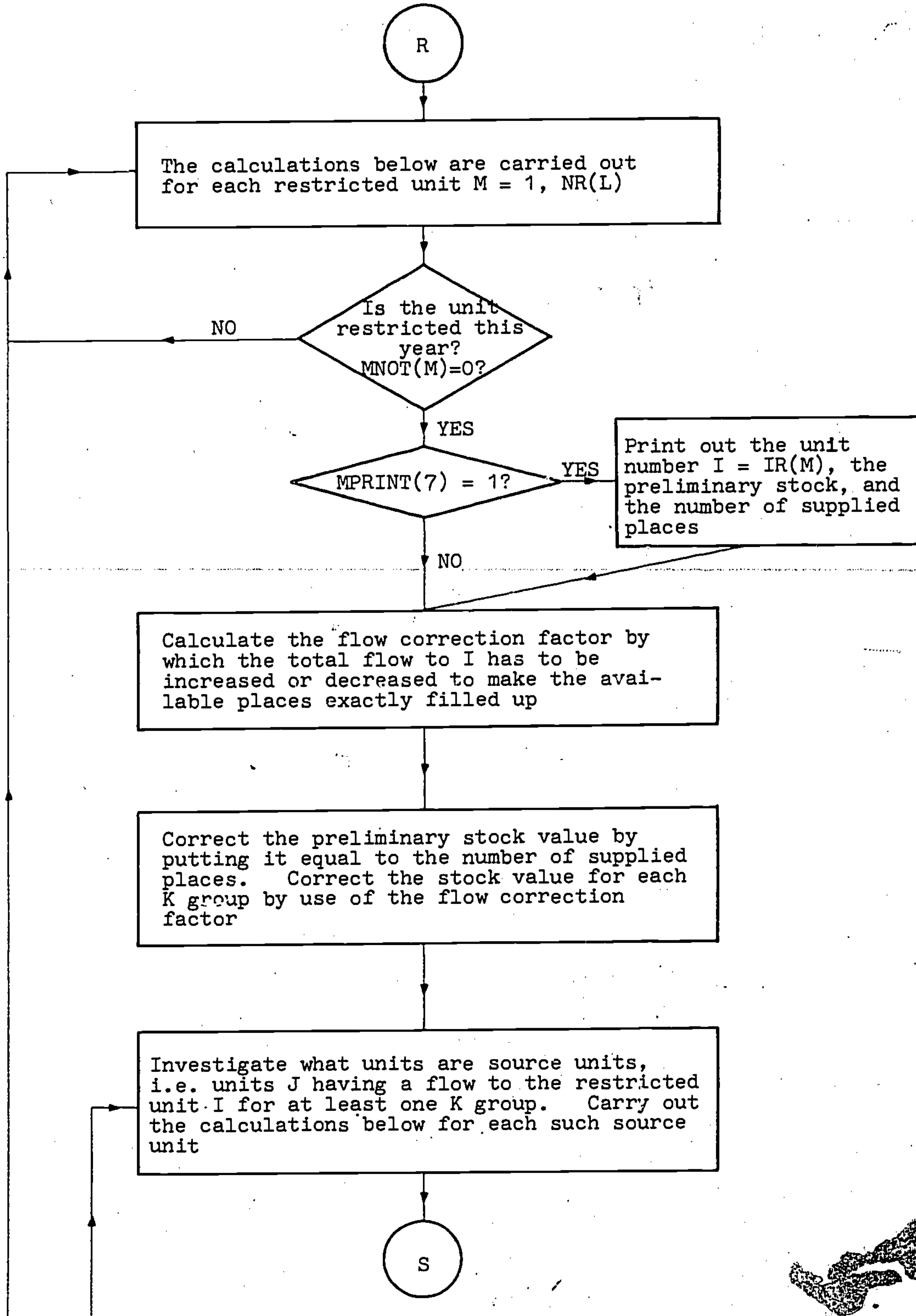
FLOW SUBPROGRAMME

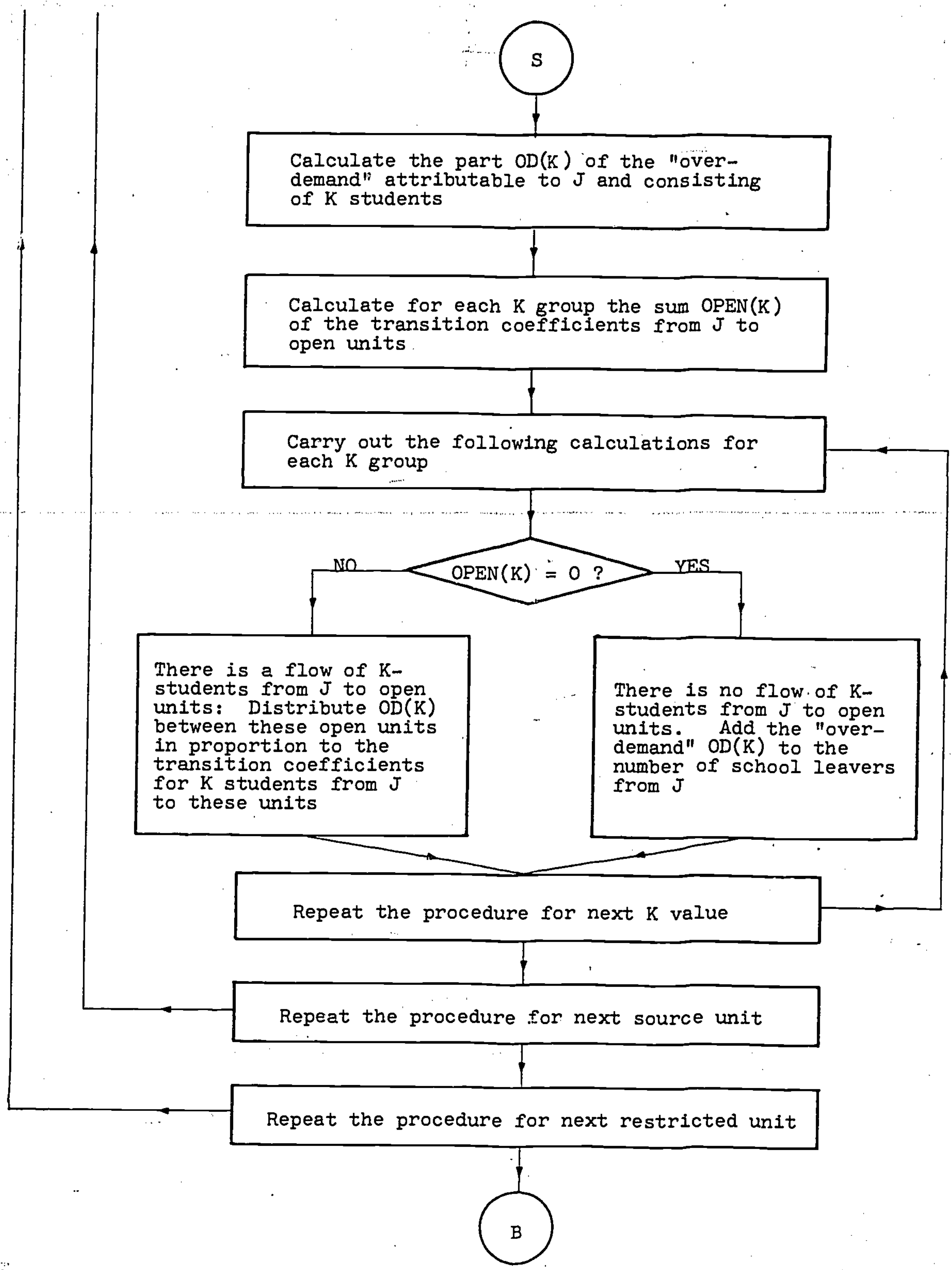



A
Calculate the repeaters, dropouts and school leavers for each unit for the end of the previous year
L = 1?
YES
NO
Distribute the new enrolments between the entry units I = 1,NUF(1) and between different K groups
Put the new student stock in the lower units equal to the one already calculated for the corresponding units in the previous level
Add to the new student stock in each unit the number of repeaters and the flow from other units in the same level
Are there restricted units?
YES
R
NO
B
Return from the restricted entry section
Calculate total stock and total number of dropouts and school-leavers for the level
C


C
L = 1?
NO
YES
KPRINT(4) = 1?
YES
Print out the number of children entering the educational system
NO
KPRINT(1) > 0?
YES
Print out the number of dropouts from each unit (and for each K group if KPRINT(1) = 1)
NO
KPRINT(2) > 0?
YES
Print out the number of school leavers from each unit (and for each K group if KPRINT(2) = 1)
NO
KPRINT(3) > 0?
YES
Print out the student stock for each unit (and for each K group if KPRINT(3) = 1)
NO
End of calculations for level L. Repeat the calculations for next level if any
N

Restricted Entry Section




S
Calculate the part OD(K) of the "over-demand" attributable to J and consisting of K students
Calculate for each K group the sum OPEN(K) of the transition coefficients from J to open units
Carry out the following calculations for each K group
NO
OPEN(K) = 0 ?
YES
There is a flow of K-students from J to open units: Distribute OD(K) between these open units in proportion to the transition coefficients for K students from J to these units
There is no flow of K-students from J to open units. Add the "over-demand" OD(K) to the number of school leavers from J
Repeat the procedure for next K value
Repeat the procedure for next source unit
Repeat the procedure for next restricted unit
B

Appendix 2

RESOURCE SUBMODEL

The Resource Submodel is used to calculate resource requirements for each of the levels from the first one to level NML. (Notations in block letters are used to denote input data to the model). NML may be inferior to the number of levels (=NMLF) for which the Flow submodel is used. It is thus, for instance, possible to use SOM to calculate future student stocks for the entire educational system but to limit the resource calculations to primary and secondary school.

As mentioned in the main text, we distinguish between direct and indirect resource requirements. They are calculated in two separate subprogrammes, called RESD and RESI, respectively, which can be used independently, that is one can use either of them or both. The relationships between calculated quantities and inputs are quite simple in most cases, and it is thus hardly necessary to give a detailed description of all these relationships. We will limit the presentation below to give some general information about the inputs, the relationships and the outputs for the main calculations of the model. The direct and indirect resource subprogrammes are described separately overleaf.

I. DIRECT RESOURCES

The following main types of operations are performed:-

i) Physical requirements (teachers, space, equipment)

ii) Physical investments (space, equipment)

iii) Teacher salaries and other current costs

iv) Capital costs corresponding to the calculated physical investments.

One can choose what calculations one wants to be carried out by use of a "steering vector" IN(I). IN(I) is put equal to 1 if one wants calculation type I to be performed. There are the following choices:

IN(1): Calculation of teacher salaries. (If IN(3) = 0, that is if teacher requirements are not calculated, teacher salaries are not calculated even if IN(1) has been put equal to 1).

IN(2): If IN(2) = 1 other current costs than teacher salaries, that is maintenance costs for space and equipment are calculated. If IN(2) = 2 current costs are calculated directly on the basis of the current cost per student, COSTPS, which is then read in as an input, and not on the basis of calculated physical resource requirements.

IN(3): Calculation of teacher requirements.

IN(4): Calculation of space requirements, that is number of rooms (classrooms and special rooms) and corresponding area.

IN(5): Calculation of equipments.

IN(6): Calculation of capital costs corresponding to the calculated "investments".

IN(7): IN(7) has to be put equal to 1 if one wants to use the direct resource subprogramme RESD. IN(8) = 1 means that the indirect resource subprogramme RESI should be used.

Direct Physical requirements

The direct physical resources, that is, teacher, space and equipment requirements, are calculated separately for each unit and activity and then summed up for the different activities and units. Calculations concerning each of these three types of resources can be excluded if so desired, (see IN(3), IN(4) and IN(5) above).

For each unit and activity a card with the following three types of input data are read in:-

(i) general activity data, that is:

activity code number (NOACT)

weekly hours or periods (WHC)

class-size (CLSZ), if different from the normal one

proportions of students taking the activity (PERC)

(ii) equipment data, that is:

equipment code number (NEQ)

utilisation ratio in percentage (EQCOEF)

additional current cost (CURST)

(iii) teacher data, that is:

teacher category code number (NQ)

ratio of the required teaching hours handled by teacher of category NQ (PQ)

weekly teaching obligations (WHT)

yearly teacher salary (SAL)

For each unit and activity the first step is the calculation of class hours (= *chours*) on the basis of (i), i.e. the general activity input data, and the total number of students (= *stud*) in the unit, calculated in the Flow submodel.

$$chours = stud * WHC * PERC/CLSZ$$

<u>The required number of teachers</u> is obtained from the number of class hours and the weekly teaching obligations (= *chours*/WHT). It may happen that different teacher categories are required for the same activity and unit and that the different categories have different teaching obligations and different salaries. This depends on how the activities and the teacher categories have been defined. If, for instance, science has been defined as one activity and Math teachers, Chemistry teachers etc. are defined as different teacher categories, we need several teacher categories for the same activity. In this case a set of the teacher input data (iii) listed above is read in for each teacher category as well as the number (= NTE) of different teacher categories. The required number of teachers of each category NQ(k) is then obtained as

$$chours * PQ(k) / WHT(k)$$

Certain summary results as to teacher requirements are calculated such as:

a) total requirements for each unit (Table 2)

b) total requirements for each category for each level (Table 12)

c) total requirements of each category for the different levels together (Table 12)

The tables mentioned above within brackets refer to computer outprint tables, the content of which is outlined in the flow-chart at the end of this Appendix.

The pupil/teacher ratio is calculated for each unit as the ratio between the total number of pupils and the total number of teachers in the unit (result printed out in Table 2).

It should be observed that the number of teachers only depends on the pupil/teacher ratio and the number of pupils. This means that it does not matter for the teacher calculations if data on, for instance, weekly periods for the pupils and weekly teaching obligations are not available if the pupil/teacher ratio is known. In this case any data for weekly periods and teaching obligations can be used if they correspond to the correct pupil/teacher ratio.

After the teacher requirements have been calculated for the activity the corresponding teacher salaries are calculated (if IN(1) = 1).

The next step in the calculations concern space requirements. The type of space required is obtained from the activity code number (NOACT, see (i) above) as the space code number has been assumed to be a direct function (NSP(NOACT), a vector read in as input) of the activity code number. Furthermore, the calculations of space requirements are based on the assumption that the rooms are required for the same number of weekly hours as the corresponding activity. The room area is assumed to depend only on type of space and class size, and to be a linear function of class size (= AA(NS) + BB(NS) * CLSZ, NS is the space code number).

The number of rooms required is obtained by dividing the number of class hours by the average utilisation time (= WSP(NS)) of the room type in question. The corresponding area is obtained after multiplication by area per room.

Certain summary results for space requirements are calculated and can be printed out:

a) room requirements by type and unit (Table 4)

b) area requirements by type and unit (Table 5)

c) room requirements for each block of units and for the level (Table 7)

d) area requirements for each block of units and for the level (Table 8)

After the area requirements for an activity in a unit has been calculated the corresponding current cost is obtained (if IN(2) = 1) by multiplication with the current cost per square unit (= CURSP(NS) for space type NS).

Equipment requirements are calculated if IN(5) = 1 and if NEQ ≠ 0, that is if any specific equipment is used for the activity in question. The calculations are analogous with those for space requirements with the exception that the required number of equipments is multiplied by a utilisation coefficient (= EQCOEF) as the equipment, e.g. a T.V. set, may not be required the entire time of the activity.

Current costs are obtained by multiplying by the corresponding unit cost (CUREQ(NEQ)). To this cost is added a current cost for "equipments" which have not been given special code numbers but only taken into account by an annual cost (= CURST) per student for the activity in question. School-books are an example of equipment which may be treated as such an annual student cost if one is not interested in calculating the required number of different school-books.

Current costs

Certain summary current costs are calculated on the basis of the current costs, obtained for each unit and activity:

a) current cost per unit (Table 2)

b) current cost per student for each unit and for the level (Table 2)

c) current costs per blocks of unit

d) teacher salaries, space maintenance costs and total current costs for each type of activity (Table 3)

Sometimes the data needed for the calculation of physical requirements and the conversion of them to current costs are not available or sometimes the current costs per student have already been estimated. The resource model can also accept the (direct) current cost per student for each unit as inputs. (IN(2) = 2). On the basis of these inputs it then calculates the current cost per unit, block and level.

Investments

The investment requirements over a certain period of time depend, of course, on the existing stock of various resources and on future requirements. The extent to which the existing stock can be used for the original or for other purposes is also of importance. It is, for instance, usual that there is a migration from rural areas to urban areas. It may, therefore, happen that existing school-buildings are not fully utilised. If under-utilisation is frequent, the various school forms have to be given different unit numbers (or rural and urban areas can be simulated separately) and the rural units counted to blocks different from corresponding urban units. The model then calculates the investments required for each block by subtracting a "comparison stock" from the calculated resource requirements. When calculating the required investments between year T1 and T2 the comparison stock should, of course, equal the existing stock year T1. However, if T1 is a future year this stock is usually not known. The same often seems to be the case even when T1 is the present year (called the base year for the model). The present computer programme is therefore so designed that the resource requirements for the base year are calculated and taken as comparison stock. If there is a shortage (or over-supply) for the base year, this should be added to (over-supply subtracted from) the investment requirements calculated by the model.

The calculation of investments for each block is based on the assumption that resources can be shared within blocks but not between different blocks. The calculation of total investments for the level assumes that resources cannot be shared between blocks if NSHARE = 0 and that they can be shared if NSHARE = 1.

Calculated room investments for each block and level are printed out in Table 7 and the corresponding area investments in Table 8. Required equipment investments are given in Table 9.

Capital costs

In principle, the capital costs equal the acquisition costs that correspond to the investment requirements. Capital costs are calculated for each type of space and equipment from the calculated investments and the capital cost per square unit [= CAPP(1,NS)] of space type NS and the capital cost per piece of equipment [= CAPP(2,NEQ)]. The calculations of capital costs by type and block (Table 10), are based on the assumption that resources can be shared within blocks but not between different blocks. Total capital costs by block and for the level for space and equipment together are printed out in Table 11.

The capital costs are obtained for the total time period between the base year and the year under consideration. How these costs are distributed between various annual budgets cannot be calculated directly as this depends on acquisition time, contract conditions, etc.

The calculations described above are illustrated by a Flow chart on pages 58 to 63. The calculations are repeated for each level and for each simulation year.

Required input data have partly been presented above in connection with the description of their use in the programme. The input data requirements are given below for each type of resource to give a more complete picture of how the different resources are described.

Space input data:

NSPACE: Number of different types of space, the need of which is directly connected to the curriculum. The definition of the space code number NS as well as NSPACE may vary between levels ($NSPACE \leq 6$).

AA(NS):
BB(NS): Area coefficients. The same code number (direct requirements) has been assumed to imply the same current (maintenance) cost and investment cost per square unit, but the area may vary with the class size CLSZ.

$$area = AA(NS) + BB(NS) * CLSZ$$

BB is put equal to 0 if the area is independent of class-size.

NSP: NSP(NOACT) is a vector defining the space code number as a function of the activity code number NOACT. ($NOACT \leq NACT$). The activities have to be so defined that the same activity code number always corresponds to the same type of space. NSP = 0 if space is not required for the activity in question. NACT is the maximum activity code number ($NACT \leq 35$).

WSP: WSP(NS) is a vector defining the number of hours per week that space type NS can be used ($NS \leq 6$).

CURSP: CURSP(NS) is a vector defining the current cost per square unit for space type NS. CURSP thus corresponds normally to the yearly class room maintenance costs including certain equipment. ($NS \leq 6$).

CAPP: CAPP(1,NS) is the capital cost (acquisition cost per square unit of space type NS).

Equipment input data:

NEQM: Number of different types of equipment, the need of which is directly connected to the curriculum. The definition of the equipment code number NEQ as well as NEQM may vary between levels ($NEQM \leq 5$). Only more important equipment (T.V. sets, computers, etc.) is taken into account this way. Equipment that directly belongs to the classroom (e.g. blackboards, chairs, chalk, etc.) does not need to be treated separately, but can be included in the space calculations. Their costs have then to be included in the corresponding current and capital space cost (cf. CURSP(NS) and CAPP(1,NS)). Equipment for which one does not want to calculate required investments and the need for which can be considered to be proportional to the number of students, e.g. school-books, can be treated by including their yearly cost in CURST, which can be read in for each unit and activity.

NEQ, EQCOEF: For each activity and unit that a piece of equipment is needed one reads in its code number NEQ and utilisation coefficient EQCOEF on the activity data card.

WEQ: WEQ (NEQ) is a vector defining the number of hours per week that equipment type NEQ can be used. (NEQ≤5).

CUREQ: CUREQ(NEQ) is a vector defining the current cost, that is in principle the maintenance cost, for each piece of equipment type NEQ (NEQ≤5). (cf. definition of CURST and NEQM).

CAPP: CAPP(2,NEQ) denotes the capital cost per piece of equipment of type NEQ.

Input data of investment calculations

NBLOCK: NBLOCK(I) is a vector defining the code number of the block to which the unit I belongs. If, for instance, NBLOCK(3) = 2, then unit 3 belongs to block 2 (cf. definition of MBLOCK and NSHARE). Each unit is assumed to belong to one and only one block.

MBLOCK: Number of blocks in the level in question. Blocks are defined as groups of units for which one wants to calculate resource requirements and/or investments and/or capital costs. (0≤MBLOCK≤5). The choice of blocks has a specific meaning for investment calculations, see definition of NSHARE. The block concept is also used in connection with the calculation of indirect resource requirements.

NSHARE: Code number defining resource sharing alternative. If NSHARE = 0, one assumes that resources can be shared between units within the same block but not between blocks. This means, for instance, that if the resource requirements for one block for year T have increased in comparison with the base year but decreased for another block, the under-utilised resources for the second block cannot be used for the first block. The total increased resource need for the first block is thus counted as required investments. NSHARE = 1 means that resources can be shared between all the units in a level.

Variation of input data

All input data listed above can vary between levels. NML, IN (see page 50), MAXNQ, LPRINT and CIND are the same for all levels.

MAXNQ: Total number of categories of teachers.

LPRINT: Outprint selection vector. LPRINT(I) = 1 if table I should be printed out.

CIND: CIND(I), (I = 1,4) is a vector denoting the yearly cost increase factor for current costs. The increase may, for instance, be due to inflation or salary negotiations. CIND is constant for each year of the simulation.
CIND(1) is the cost increase factor for space. The yearly current cost for one square unit of space type NS year T is thus assumed to be:

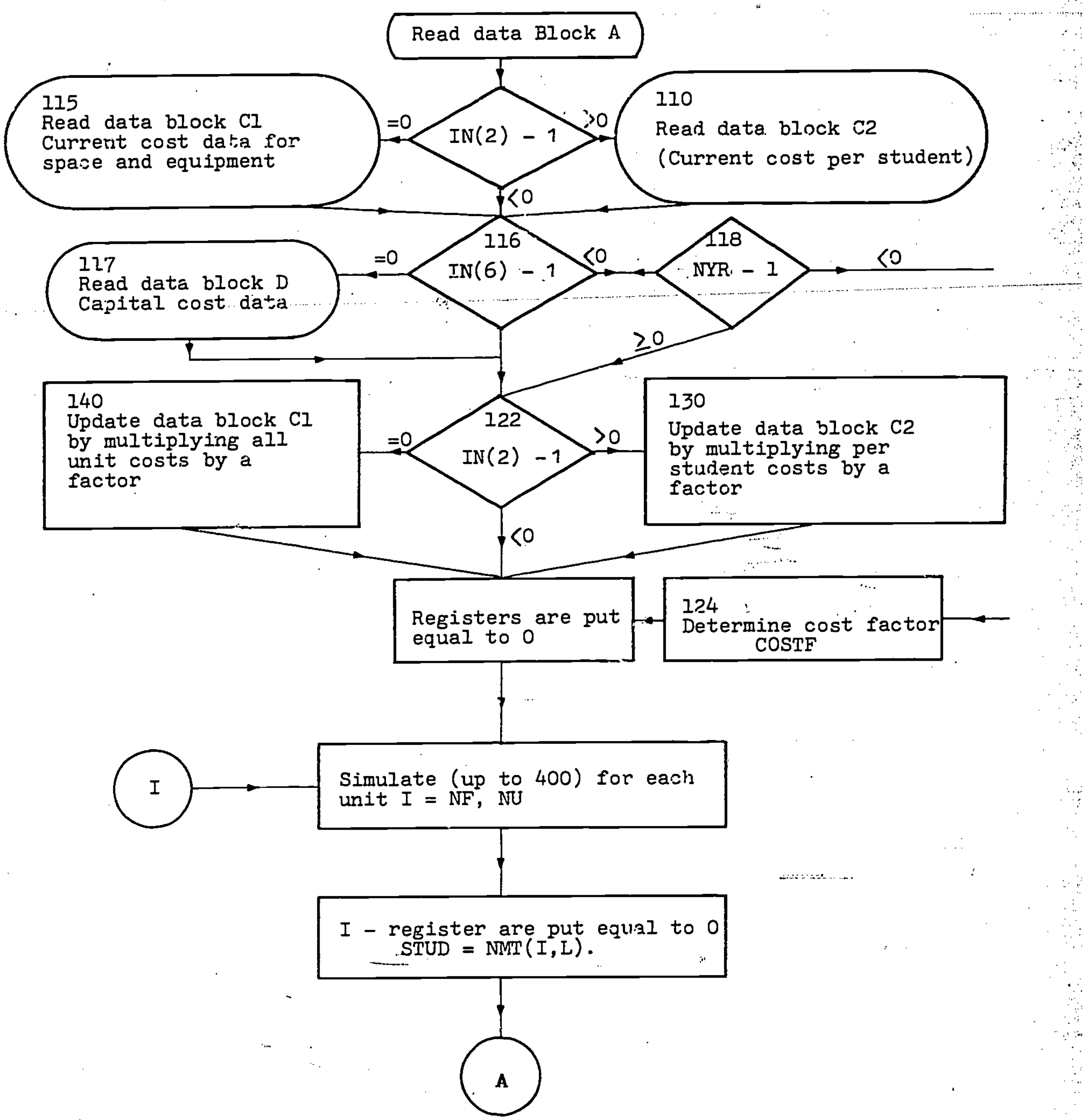
$$\text{CIND}(1)^{T} * \text{CURSP(NS)}$$

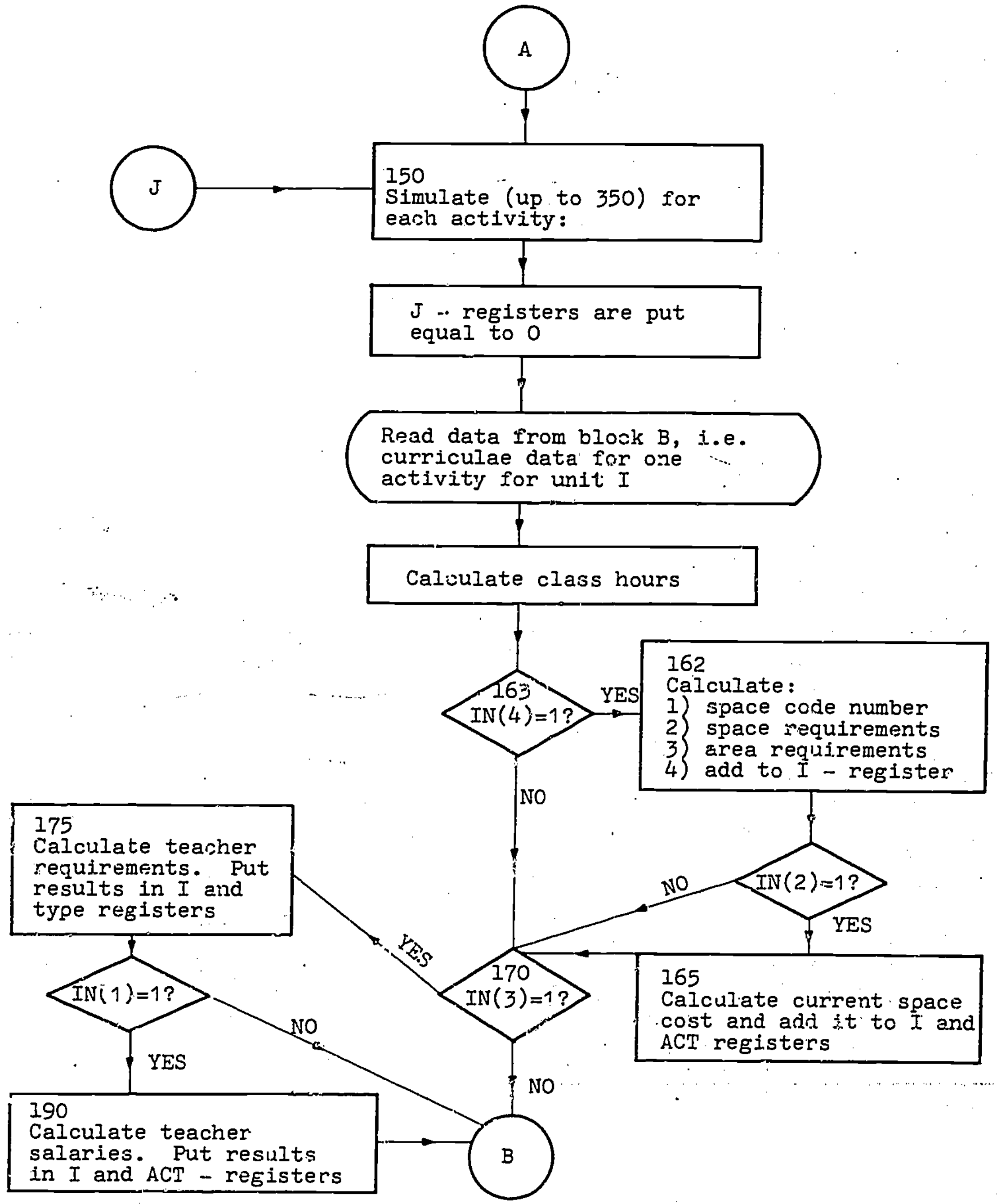
CIND(1) should thus be put equal to 1 if there is no cost increase.
CIND(2) is the corresponding cost increase factor for equipment and CIND(4) for teachers' salaries.
If costs are calculated on the basis of current costs per student (cf. IN(2) = 2 and COSTPS) the cost increase factor for COSTPS is CIND(3).

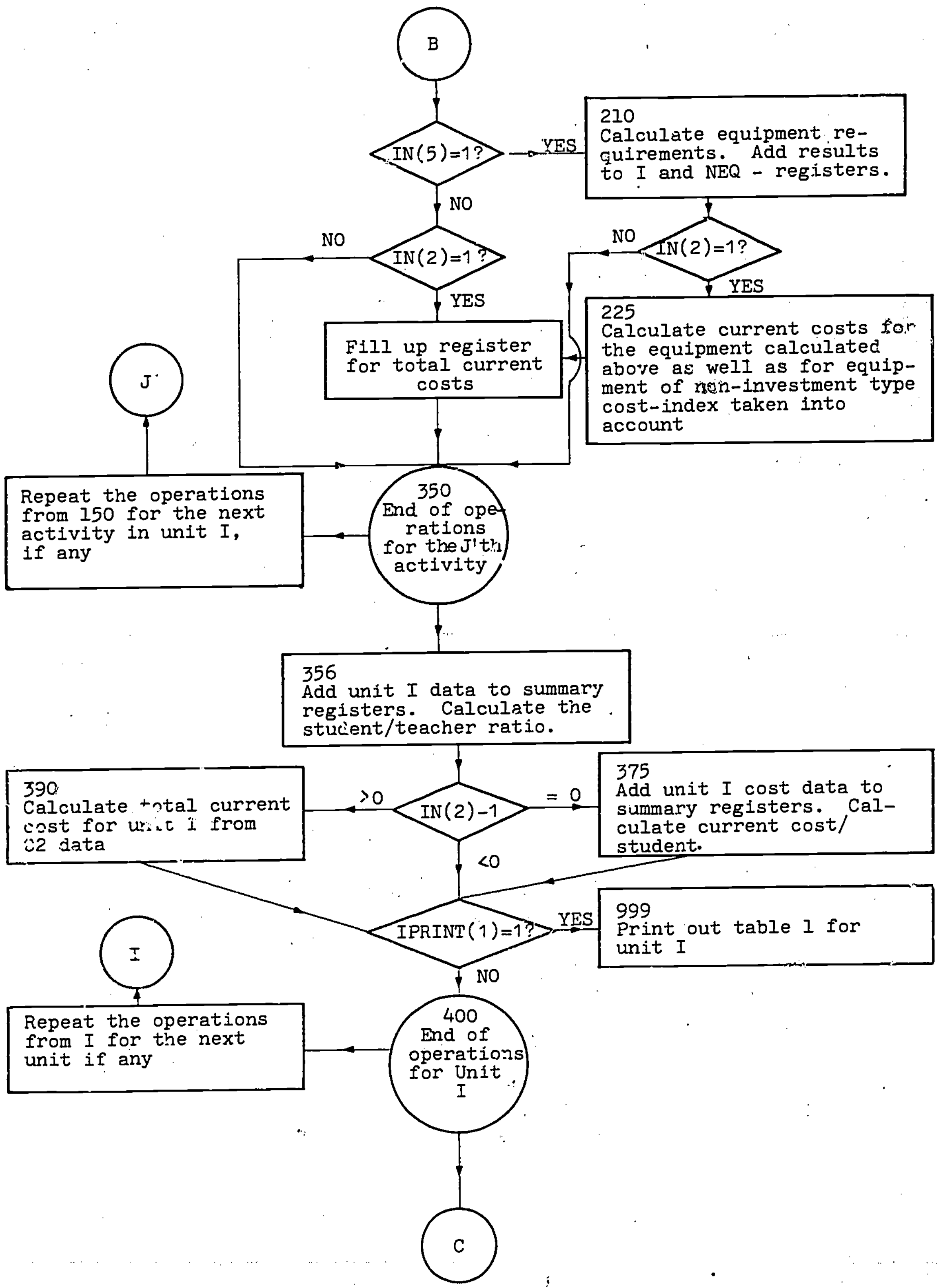
All input data have been assumed constant over time except the current cost data which can be adjusted by use of the cost index CIND defined above.

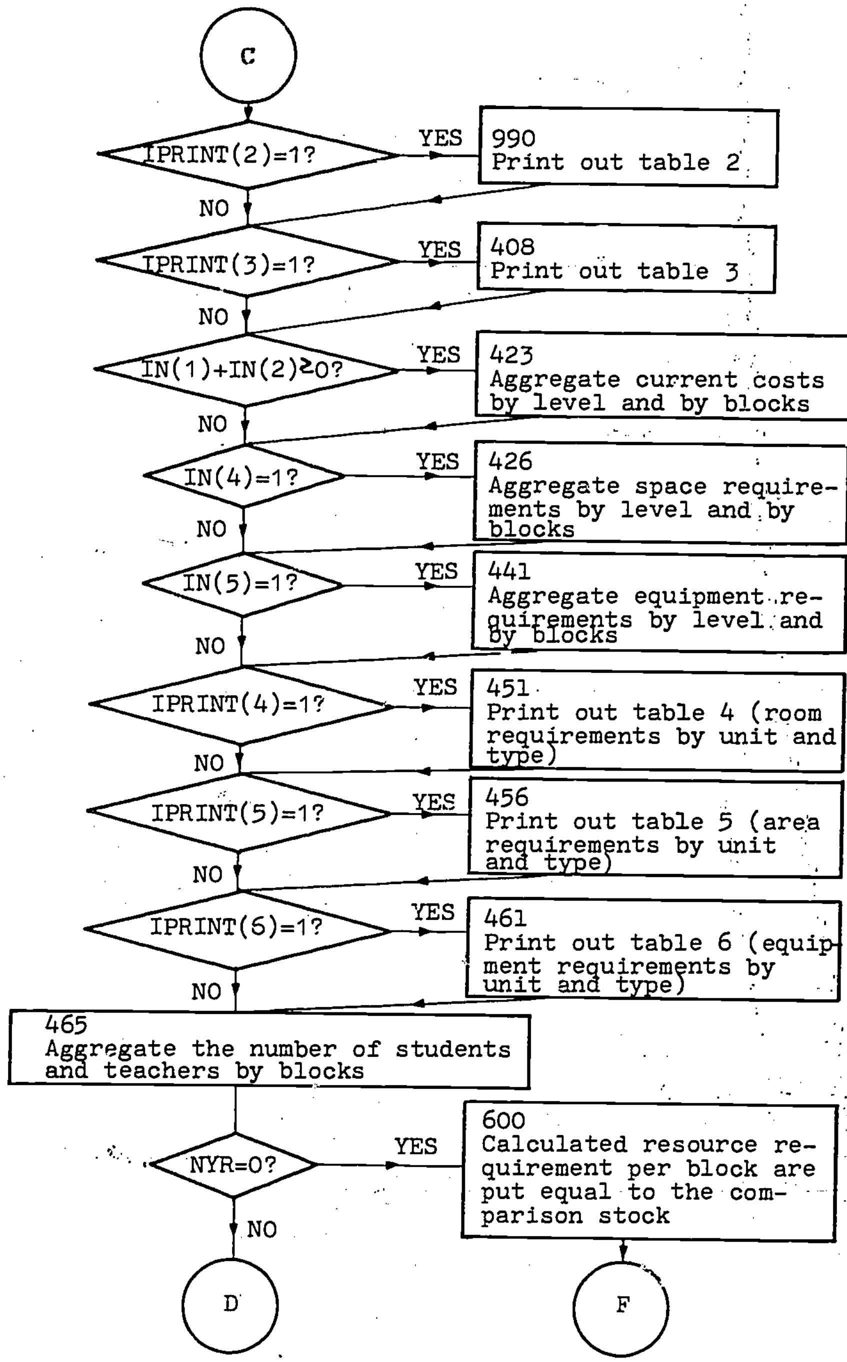
A complete description of input data formats and the RESD subprogramme is given in Part II of this report. A general description of the organisation of the calculations in the programme is given in the flow chart following.

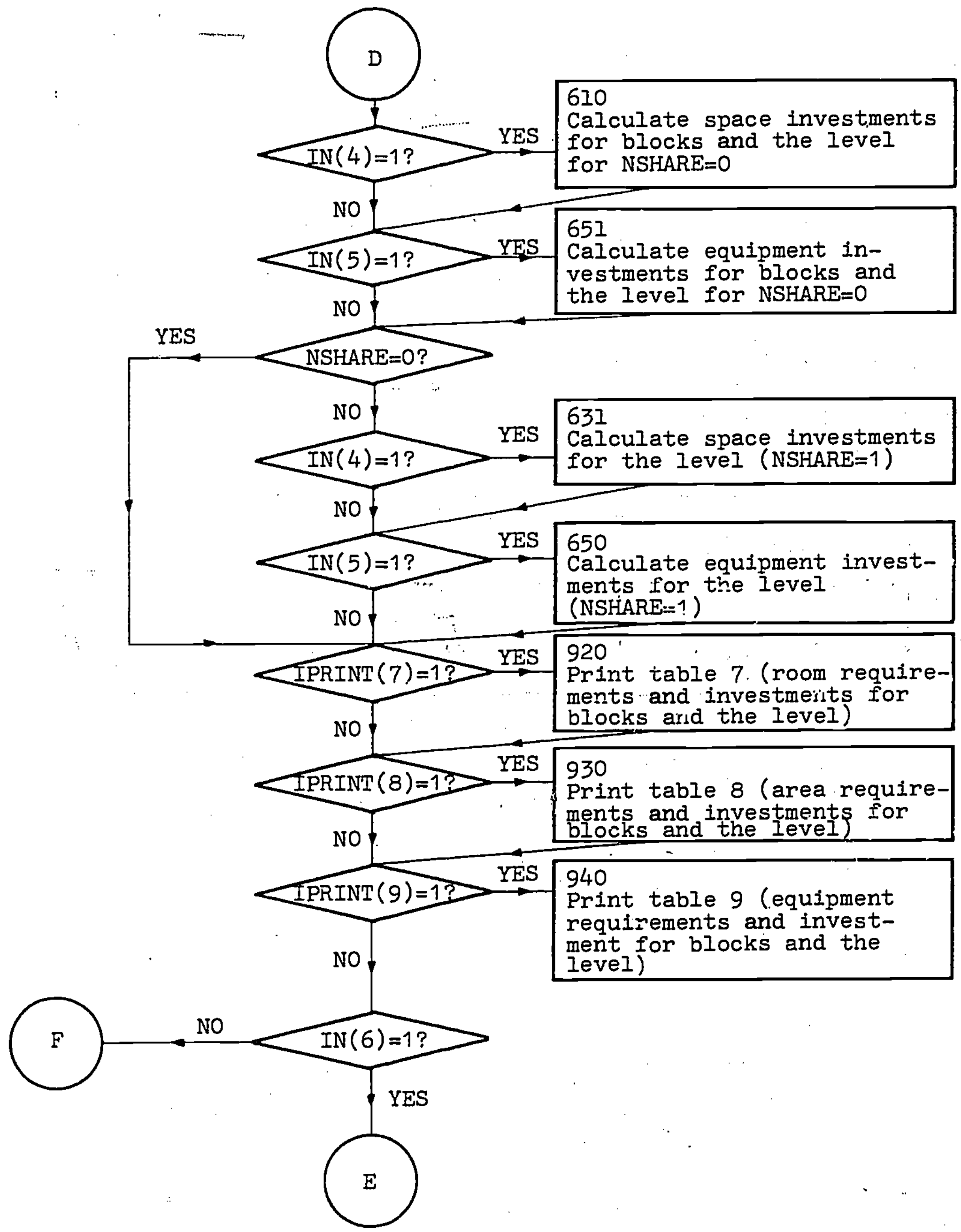
RESOURCE SUBMODEL (DIRECT REQUIREMENTS)

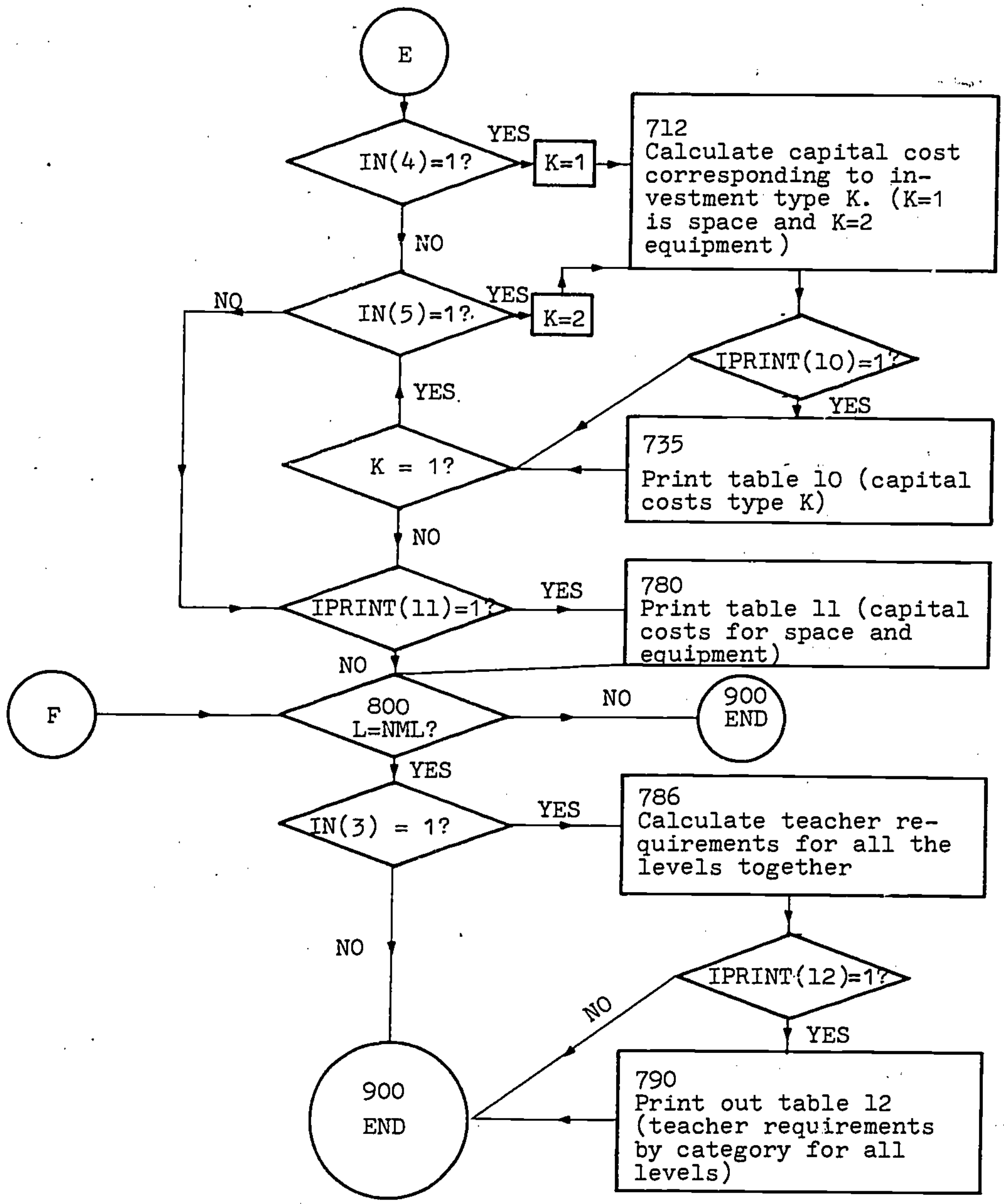



A
J
150
Simulate (up to 350) for each activity:
J - registers are put equal to 0
Read data from block B, i.e. curriculae data for one activity for unit I
Calculate class hours
163
IN(4)=1?
YES
162
Calculate:
1) space code number
2) space requirements
3) area requirements
4) add to I - register
NO
175
Calculate teacher requirements. Put results in I and type registers
IN(2)=1?
NO
YES
YES
170
IN(3)=1?
165
Calculate current space cost and add it to I and ACT registers
IN(1)=1?
NO
YES
NO
190
Calculate teacher salaries. Put results in I and ACT - registers
B


B
IN(5)=1?
YES
210
Calculate equipment requirements. Add results to I and NEQ - registers.
NO
IN(2)=1?
NO
IN(2)=1?
NO
YES
YES
Fill up register for total current costs
225
Calculate current costs for the equipment calculated above as well as for equipment of non-investment type cost-index taken into account
J
Repeat the operations from 150 for the next activity in unit I, if any
350
End of operations for the J'th activity
356
Add unit I data to summary registers. Calculate the student/teacher ratio.
390
Calculate total current cost for unit I from C2 data
>0
IN(2)-1
= 0
375
Add unit I cost data to summary registers. Calculate current cost/student.
<0
IPRINT(1)=1?
YES
999
Print out table 1 for unit I
I
NO
Repeat the operations from I for the next unit if any
400
End of operations for Unit I
C


C
IPRINT(2)=1?
YES
990
Print out table 2
NO
IPRINT(3)=1?
YES
408
Print out table 3
NO
IN(1)+IN(2)≥0?
YES
423
Aggregate current costs by level and by blocks
NO
IN(4)=1?
YES
426
Aggregate space requirements by level and by blocks
NO
IN(5)=1?
YES
441
Aggregate equipment requirements by level and by blocks
NO
IPRINT(4)=1?
YES
451
Print out table 4 (room requirements by unit and type)
NO
IPRINT(5)=1?
YES
456
Print out table 5 (area requirements by unit and type)
NO
IPRINT(6)=1?
YES
461
Print out table 6 (equipment requirements by unit and type)
NO
465
Aggregate the number of students and teachers by blocks
NYR=0?
YES
600
Calculated resource requirement per block are put equal to the comparison stock
NO
D
F


D
IN(4)=1?
YES
610
Calculate space investments for blocks and the level for NSHARE=0
NO
IN(5)=1?
YES
651
Calculate equipment investments for blocks and the level for NSHARE=0
NO
YES
NSHARE=0?
NO
IN(4)=1?
YES
631
Calculate space investments for the level (NSHARE=1)
NO
IN(5)=1?
YES
650
Calculate equipment investments for the level (NSHARE=1)
NO
IPRINT(7)=1?
YES
920
Print table 7 (room requirements and investments for blocks and the level)
NO
IPRINT(8)=1?
YES
930
Print table 8 (area requirements and investments for blocks and the level)
NO
IPRINT(9)=1?
YES
940
Print table 9 (equipment requirements and investment for blocks and the level)
NO
F
NO
IN(6)=1?
YES
E


E
IN(4)=1?
YES
K=1
712
Calculate capital cost corresponding to in-vestment type K. (K=1 is space and K=2 equipment)
NO
IN(5)=1?
YES
K=2
NO
IPRINT(10)=1?
YES
735
Print table 10 (capital costs type K)
K = 1?
YES
NO
IPRINT(11)=1?
YES
780
Print table 11 (capital costs for space and equipment)
NO
F
800
L=NML?
NO
900
END
YES
IN(3) = 1?
YES
786
Calculate teacher re-quirements for all the levels together
NO
IPRINT(12)=1?
NO
YES
790
Print out table 12 (teacher requirements by category for all levels)
900
END

II. INDIRECT RESOURCES

The calculation of indirect resource requirements is carried out in the subprogramme RESI.

Indirect or additional resource requirements consist of those educational resources which are not directly connected with the curricula. Functions other than the teaching function may, for instance, be:

Administration
Medical and Social Services
Libraries
Scholarships and subsidies paid out to students.

Such support functions are usually proportional to the number of students and fairly independent of unit number within certain limits. Obviously, primary schools and universities require quite different types of libraries, etc. To what extent there are variations within the same level depends on how the levels have been defined. The model design is based on the assumption that the requirements are proportional to the number of students in each block and that the factor may vary between the different blocks of a certain level and between levels.

There may be resource requirements which are not generated directly by the students. Research facilities for instance, may be required by university teachers. Such a possibility has been taken into account in the model by the introduction of a code number (see definition of NNI below) which defines what factor (the number of students or teachers, for instance) is the generator of the resource requirements.

There are various more or less detailed methods of simulating indirect resource requirements. In a detailed simulation one could use the number of different types of "items" (nurses, administrators, offices, library books, etc.) per student, as input data, and then calculate total requirements both for the items and along functional lines. This may be a desirable approach on lower decision levels (e.g. individual schools). On higher decision levels, however, input information about less important "items" is not available, nor is output information concerning such items of interest. As the cost estimates will be biased downwards if not all items are included, we have chosen another more aggregated and function-orientated approach in the model.

As input (= MATF) for each block we use the number of students (or teachers) which corresponds to one "unit" of different functions, for instance, 500 students require one library of normal size. For each resource type IB the corresponding area (= ARC(1,IB)) current cost (= ARC(2,IB)) and capital cost (= ARC(3,IB)) are given as input.

Of primary interest is the following output information:

(i) total requirements as to certain key types of personnel and space;

(ii) total requirements for each level and for blocks of units as to space, current costs, and capital costs for each main function and for all the functions together.

We will illustrate by an example how input data have to be defined to obtain these two types of output.

A medical service usually required personnel (doctors, nurses, etc.) and space and equipment. We define a normal size medical function, with:

(1) the area required (= ARC(1,1));

(2) the annual cost which thus includes salaries, maintenance costs for space and durable equipment and acquisition costs for non-durable pieces of equipment (= ARC(2,1)); and

(3) the capital cost which equals the set-up cost of a new installation (= ARC(3,1)).

The computer programme then calculates the total number of installations and corresponding space requirements and current costs in the country or school district being studied. By comparing the requirements with the comparison stock (i.e. base year's requirements, cf. page 54) required investments and capital costs can then be calculated. This gives us output information of type (ii) but not directly data of type (i); for instance, not the number of doctors required. This can be obtained indirectly by deducing it from the calculated number of medical "functions" required. It can, however, also be obtained directly from the model by adding one fictitious function and corresponding data, that is the average number of pupils or students that corresponds to the need of one doctor. To avoid double-counting, the new "object" or function has to be associated with zero current cost (obviously also 0 space and capital cost) as the doctors' salaries already have been included in the general input data for the medical function.

If one does not want to calculate costs, one can exclude the cost calculations by use of the steering-vector INN. Current and capital costs are not calculated when INN(1) and INN(2), respectively, are put equal to 0.

JPRINT(I) is a printing vector which is put equal to 1 if table I should be printed out, otherwise JPRINT(I) = 0.

All input data except INN, JPRINT and COSTFI (a cost-index) may vary between levels but not between different simulation years. The unit current cost can still be made to vary over time by use of the cost-index COSTFI. For each simulation year T the unit current cost for the resource type IB is calculated in the programme as:

$$ARC(2,IB) * COSTFI(IB)^{T}$$

COSTFI(IB) should thus be put equal to 1 if the current cost for a "unit" of resource type IB does not change over time.

If the direct resource subprogramme RESD is not used, certain data that otherwise would have been inputs to RESD or calculated in RESD have to be inputs to the indirect resource subprogramme RESI. This is true for NSHARE, MBLOCK, NBLOCK (see pp. 55-56) and JTRG. JTRG(1,J) is the required number of teachers in block J. JTRG is only needed as an input if there are any requirements of indirect resources that depend on the number of teachers. A code number (NNI) determines whether the required resources depend on the number of students or the number of teachers in the block.

The calculated results are printed out in seven different tables. The content of each table is explained below.

Table 1 Required numbers of each resource type for each block and for the level (e.g. the required number of libraries, office rooms, doctors, etc.).

Table 2 Required area of each resource type for each block and for the level.

Table 3 Required investments, expressed in numbers, of each resource type, for each block and for the level.

Table 4 Required investments, expressed in area, of each resource type for each block and for the level.

Table 5 Required current costs of each resource type for each block and for the level.

Table 6 Required capital costs of each resource type for each block and for the level.

Table 7 If the Direct Resource submodel has also been used, certain summary results for direct and indirect resources are printed out. These are area requirements, area investments, current costs and capital costs for each block and for the level.

RESI has been designed for the calculation of indirect resource requirements, that is other resource requirements than those directly generated by the teaching function. RESI may, however, in certain cases also be used for rough estimates of direct resource requirements. If, for instance, the student/teacher ratio can be assumed constant for the different units belonging to the same block and if this constant is known, the required number of teachers and their total salaries can be calculated in RESI. Different categories of teachers can be distinguished between if the student/teacher ratio is known for each category. This ratio is not assumed known when RESD is used, but calculated in the RESD programme on the basis of such inputs as class size, curriculum data and teaching obligations.

The input data needed for RESI have been mentioned in the text above. They are listed below together with detailed definitions, and with some comments concerning differences that occur when RESI is used with or without RESD. A flow-chart illustrating the organisation of the calculations in RESI follows.

Input Data:

The variables IN, INN, JPRINT and COSTFI are the same for all levels; the others may vary between levels.

IN: IN(I) determines for I = 1,6 what calculations in RESD are to be carried out.
IN(7) = 1 if RESD should be included.
IN(8) = 1 if RESI should be included.

INN: Vector determining what types of calculations are to be carried out.
INN(1) = 1: Calculation of current costs.
INN(2) = 1: Calculation of capital costs.

JPRINT: The printing vector JPRINT(I) is put equal to 1 if table I should be printed out, otherwise JPRINT(I) = 0. Outprints for one or more of the simulated years can be skipped when one wants it; see definition of MYEARO and MYEAR(NYR).

COSTFI: COSTFI(IB), (IB = 1,10) is a cost-index vector denoting the yearly cost increase factor for current costs for object IB. COSTFI(IB) must not vary between levels.

If the Direct Resource subprogramme RESD is not used, NSHARE, MBLOCK, NBLOCK and JTRG are read in as input. NSHARE, MBLOCK and NBLOCK are defined in the same way as when they are inputs to RESD. JTRG(1,J) is the required numbers of teachers in block J. A blank card can be left for JTRG(1,J) when there are no indirect resources, the need of which depends on the number of teachers.

<u>IOBJ:</u> Number of different types of objects. IOBJ 10 IOBJ may vary between levels.

<u>NNI:</u> NNI(IB) are code numbers equal to 1 if the requirements of "object" type IB are proportional to the number of pupils in the block. NNI(IB) is equal to 2 if the requirements are proportional to the number of teachers in the block.

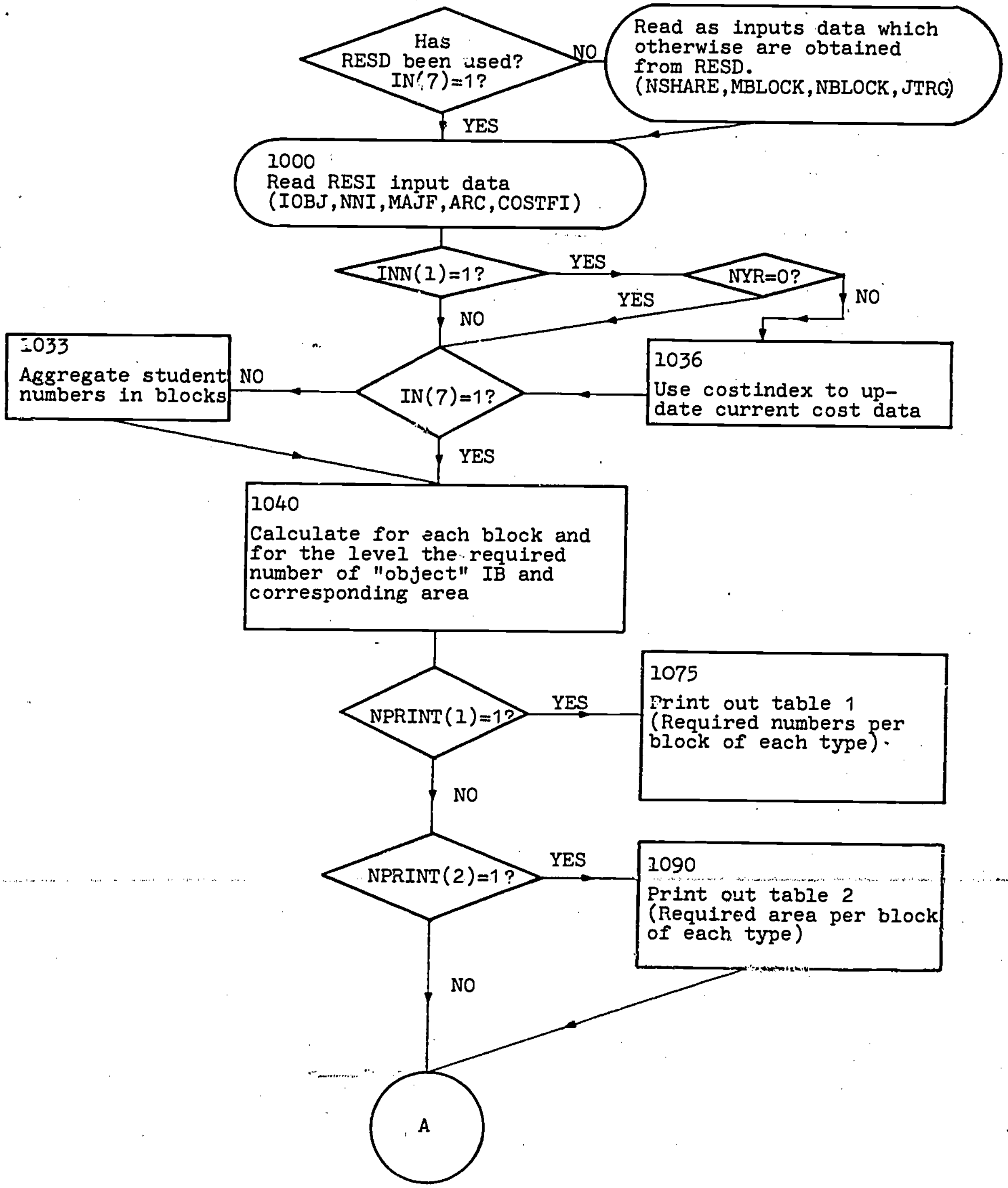
<u>MATF:</u> The elements of the matrix MATF(J,IB) define the relationship for each block J between the number of "objects" required and the number of pupils (or teachers). The number JF(1,J,IB) of objects type IB required in block J equals

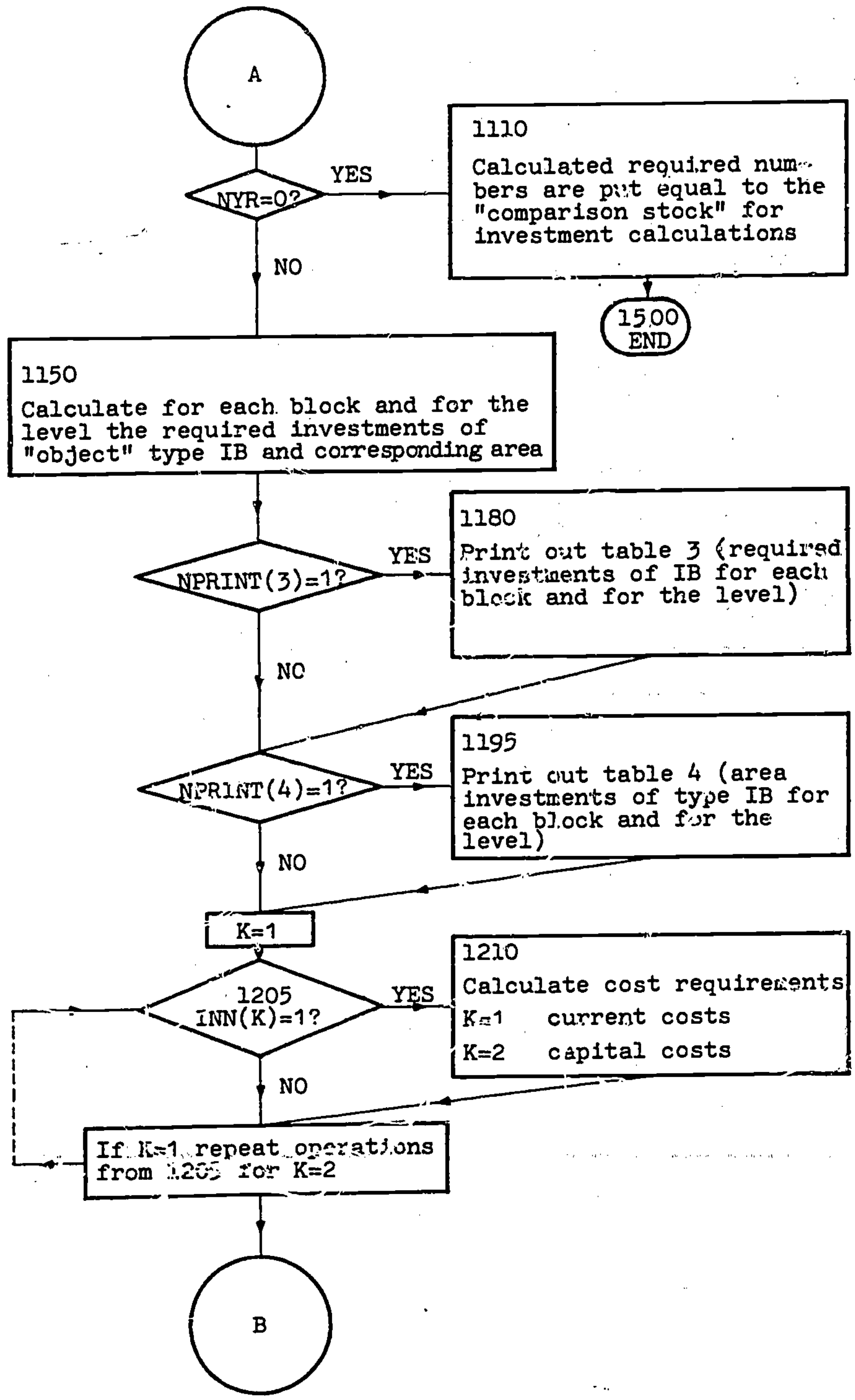
$$JF(1,J,IB) = NMTB(1,J)/MATF(J,IB)$$

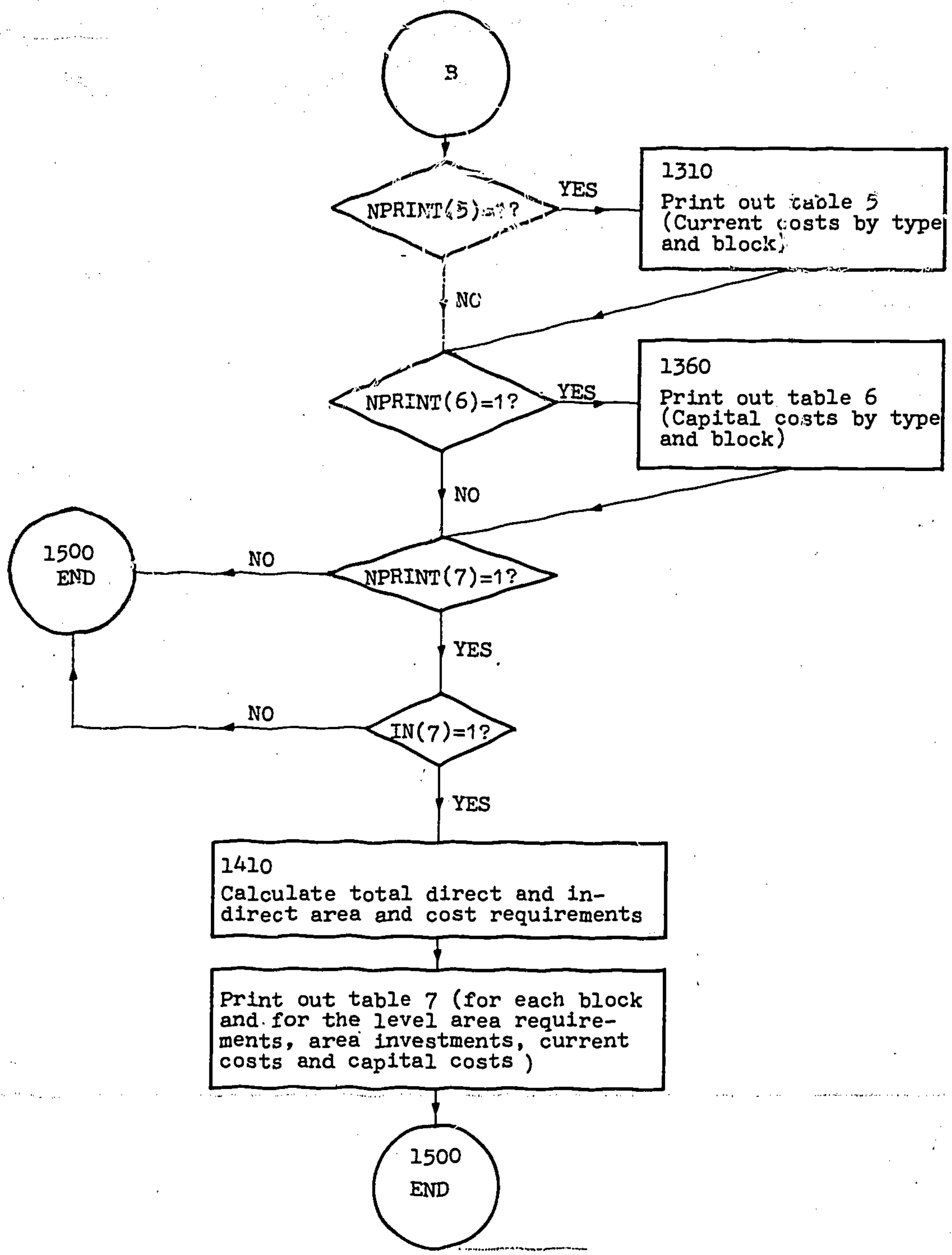
if NNI(IB) = 1.
NMTB(1,J) is the number of pupils in block J.

<u>ARC:</u> ARC(I,IB), I = 1, 2 and 3 respectively, corresponds to area, current cost, and investment cost for object IB.

INDIRECT RESOURCE REQUIREMENTS




A
NYR=0?
YES
NO
1110
Calculated required numbers are put equal to the "comparison stock" for investment calculations
1500
END
1150
Calculate for each block and for the level the required investments of "object" type IB and corresponding area
NPRINT(3)=1?
YES
NO
1180
Print out table 3 (required investments of IB for each block and for the level)
NPRINT(4)=1?
YES
NO
1195
Print out table 4 (area investments of type IB for each block and for the level)
K=1
1205
INN(K)=1?
YES
NO
1210
Calculate cost requirements
K=1 current costs
K=2 capital costs
If K=1 repeat operations from 1205 for K=2
B


B
NPRINT(5)=1?
YES
1310
Print out table 5 (Current costs by type and block)
NO
NPRINT(6)=1?
YES
1360
Print out table 6 (Capital costs by type and block)
NO
1500 END
NO
NPRINT(7)=1?
YES
NO
IN(7)=1?
YES
1410
Calculate total direct and in-direct area and cost requirements
Print out table 7 (for each block and for the level area require-ments, area investments, current costs and capital costs)
1500
END

Appendix 3

TEACHER SUPPLY SUBMODEL

The teacher supply stock divided up into different teaching categories is calculated in a subprogramme called TESU which can either be used after the Student Flow subprogramme or the Resource subprogramme.

The relationships between calculated quantities and inputs are quite simple in most cases and we will limit the presentation below to give some general information about the inputs, the relationships used and the outputs for the main calculations of the model.

The total teacher stock is submitted to the following changes at each time period:

Outflow

(1) Death

(2) Retirements

Inflow

(1) Graduates coming from the educational system

(2) Net inflow of ex-teachers and people from other activities

(3) Net inflow of immigrants

(4) Internal changes

The time t in the model is so defined that t = 0 is the base year for which the teacher stock [= TSBY(NQ)] for each NQ category is assumed to be known.

The base year stock is updated each year and denoted *tspy*(NQ) (variables in block letters are inputs to the model; the others are calculated).

1. Outflow

The calculation of deaths and retirements requires knowledge of the age distribution of the teachers. Information is assumed to be aggregated according to chosen age intervals. Following the quality of the information available two alternatives are possible for the base year input.

NAGED = 0 The age distribution can be estimated for each NQ group (teacher category) separately.

F(NQ,I) = Proportion of the number of teachers in group NQ belonging to age interval I

NAGED = 1 The age distribution can only be estimated for the total teacher stock and the model assumes that the same distribution is valid for each NQ category.

F(I) = Proportion of the total number of teachers belonging to age interval I

The change in the age distribution during the simulation period is not calculated in the model. As the number of deaths and retirements is small in comparison with the total number of teachers, the general accuracy of the model does not normally require this type of refinement. A change in the age distribution over time can be read in as input if it is estimated exogenously.

1.1 Death outflow

Death rates DR(J) as a function of age J are inputs for the base year.

The mean death rate, d(I), for each age interval I is then calculated.

The number of deaths for each teaching category (dtc(NQ)) is calculated by summing up over-all age intervals

d(I) . F(NQ,I) . TSPY(NQ) if NAGED = 0

d(I) . F(I) . TSPY(NQ) if NAGED = 1

Summary results are calculated for all categories.

1.2 Number of retirements

The necessary input data being the retirement age for each category, we distinguish between two cases:

IRET = 0 The age interval containing the retirement age is the same for all NQ categories. The number (INTR) of the age interval containing the retirement age is input.

IRET = 1 The retirement age belongs to another age interval for at least one NQ category. The number of the age interval, INT(NQ), containing the retirement age is read in separately for each category.

The two possible age distribution cases multiplied by the two possible input cases for the retirement age lead to four possible calculations. The number of retirements, ret(NQ), is obtained in the following way. If NAGED = 0 and IRET = 1, ret(NQ) = TSPY(NQ) . F(NQ,INT(NQ))/ℓ(INT(NQ)) ℓ(INT(NQ)) being the length of the age interval containing the retirement age.

2. Inflows

2.1 Graduates coming from the educational system

In order to translate the graduates from certain producing units (teacher colleges or university), we need the following input data.

A branching indicator as to the quality of information to be used.

MF = 0 The Student Flow model does not distinguish between male and female.

MF = 1 There are several student groups in the Student Flow submodel; each of them contains only male or only female students. Male groups are referred to by MG(K) = 1, and 0 otherwise.

For each level L:

- The code numbers, IR(MT), of units which "produce" teachers.
- The stock of students, NN(I,K,L), of each producing unit for year t - 1 if t is the simulation year, where I = IR(MT).
- The ratio of students from unit J who pass the examination in year t - 1 and belong to category NQ: PQ(NQ,I,L) (rate of success).
- The ratio of those from unit I who graduated in category NQ (year t - 1) and who chose the teaching profession: PP(NQ,I,L) (rate of choice).

If MF = 1 two sets of ratios are defined, one for male students and the other for female students.

The yearly addition from the educational system into category NQ (*ties*(NQ)) is obtained by summing up over-all producing units and levels the following expression (if MF = 0):

PP(NQ,I,L) . PQ(NQ,I,L) . *nts*(I,L)

where *nts* is the sum for all students groups in unit I.

The case MF = 1 leads to a similar calculation in which there are two expressions instead of one, i.e. for all (I,L)

PPO(NQ) . PQO(NQ) . *nms*+ PP1(NQ) . PQ1(NQ) . *nfs*

nms = number of male students in (I,L)

nfs = number of female students in (I,L)

Sensitivity Analysis

The Teacher Supply submodel has the imbedded possibility of running sensitivity trials as to the value of the inflow from the educational system for small variations of the "rate of success" and/or the "rate of choice". As the total stock of teachers is a linear function of different in- and out-flows, the variations in the inflow from the educational system are variations in the total stock. It has been said earlier that the "rate of success" could be interpreted as a policy variable, different values for this parameter being the measure of different policies as to the production of potential teachers. On the other hand, the "rate of choice" is the result of factors such as labour market prestige attached to the teaching profession, teacher salaries, etc. on which information is partial, so this parameter is able to vary within certain limits which translate the uncertainty of the evaluation. The calculated variations in the teacher stock could be interpreted as the likely result of different policy alternatives for the production of potential teachers.

For each ratio there is the possibility of trying three alternatives and assuming that the same type of policy is applied for each producing unit this will lead to a maximum of nine different values for the inflow from the educational system.

2.2 Net inflow of non-active ex-teachers and people from other activities

There are two cases as to the availability of data:

IDA = 0 Data can be estimated for each year of the simulation period and for each category; these data are direct inputs (NXTC(NQ))

IDA = 1 The inflow is assumed to be a constant percentage of the existing stock of teachers the previous year. The set of percentages PT(NQ) is the input for the base year, and then $nxtc$(NQ) = PT(NQ) . TSPY(NQ).

2.3 Net immigration

This net inflow, denoted NITC(NQ), is assumed to be estimated for each year and read in as input.

2.4 Internal flows

These adjustments are optional and could be skipped if desired. In the model internal flows are treated as follows:

For each NQ category

IQ	number of internal flows flowing in NQ category
NP(I)	code number of the categories having a flow to NQ
QFLOW(I)	value of the flow from NP to NQ

All these values should be input data. The updating of the teacher stock is then carried out by adding to the stock of each NQ category the flow from other groups and subtracting the corresponding values from their stock.

The Teacher Supply submodel updates the teacher stock from one year to another by:

- subtracting outflows and adding net inflows
- adjusting for internal changes.

The calculations described above are illustrated in a flow chart.

Required input data have been partly defined above in relation to their use in the programme.

The input data requirements are presented below for each type of flow calculation to give a more complete figure of how the different in- and outflows are defined.

TSBY : TSBY(NQ) is the stock of teachers of category NQ, in the base year.

MAXNQ : Maximum number of teacher categories.

<u>Inputs for the death outflow</u>

DR · DR(J) Death rate for each age J = 1, MAXAG

NINT : Number of age-intervals (NINT 9)

NAGED : Code number for the age distribution data availability form·

F : If NAGED = 0, F(NQ,I) is the proportion of the number of teachers in NQ category belonging to age interval I

FQ : If NAGED = 1, FQ(I) is the proportion of the total teacher stock in age interval I

Inputs for Retirement Outflow

IRET : IRET = 0 if the retirement age belongs to the same age interval for each NQ category.

IRET = 1 otherwise.

INTR or INT(NQ) :

Number of the age interval which contains the retirement age for IRET = 0 and IRET = 1 respectively.

Inputs for the Inflow from the Educational System

MF = 0 : no distinction according to sex of the inflow of graduates from the educational system.

MF = 1 : otherwise.

MG : MG(K) is a vector where K = 1,NSG denotes the student group. MG(K) = 1 for male student groups.

MTM : MTM(L) is a vector which gives for each level L the number of units which "produce" teachers.

For each level L

IR : IR(MT) gives the code numbers of educational units producing teachers for MT = 1,MTM(L)

KKOI : KKOI(NQ) = 0 if the category NQ is not produced for the level L processed.

KKOI(NQ) = 1 otherwise.

For each L,NQ,MT

MUP : MUP = -1 No alternative available for the "rate of choice".

MUP = 0 One alternative available, which could be smaller or greater than the "normal" value.

MUP = 1 Two alternatives are available.

MUQ : Same definition for the "rate of success".

For MF = 0

PQ : PQ(I) where I = 1,3 is a vector which contains three possible values for the "rate of success" of students from unit I = IR(MT) and level L who belong to category NQ.

PP : PP(I) contains the three possible values of the "rate of choice" of NQ-graduates unit I = IR(MT) and level L who choose the teaching profession.

For MF = 1

PQO): Rate of success for male students
PPO): Rate of choice for male students

PQ :
PP : Same definition as above but for female

Inputs for the Net Inflow of "Ex-teachers"

IDA : IDA = 0 The net inflow is read in as a direct input
IDA = 1 Otherwise

NXTC : NXTC(NQ) Net inflow of ex-teachers and people from other activities for each category. If IDA = 0, this input is read in for each year of the simulation period.

PT : PT(NQ) The net inflow is defined as a fixed percentage PT of the stock of teachers of the previous year for each category. This set of percentages is read in for the base year.

Inputs for the Net Inflow of Immigrants

NITC : NITC(NQ) Number of net immigrants for each category. This input is read in for each year of the simulation period.

Inputs for the Internal Flows

KO = 0 If there are available data for the calculation of internal changes in the teacher stock.

KO = 1 Otherwise.

IQ : IQ(NQ) gives for each category the number of categories which have a flow to NQ

NF : Code number of the category having a flow to NQ

QFLOW : Number of teachers who change from category NP to category NQ

Internal Notations

D : D(I) denotes the rate of death for age interval I

DTC : DTC(NQ) number of deaths for each category

RET : RET(NQ) number of retirements for each category

TIES : TIES(NQ,1) Number of teachers coming from the educational system for each category NQ

TIES(NQ,KA) . KA = 2,9 variation of TIES(NQ,1) following the different alternatives KA

TSPY : TSPY(NQ) Number of teachers available in each category. This stock value is updated year by year for the entire simulation period.

<u>Inputs from the Student Flow submodel</u>

NN : NN(I,K,L) Number of students belonging to group K in unit I and level L. This information contains the number of students for year t - 1 and year t if t is the simulation year. The model uses the number related to year t - 1.

NU : NU(L) Number of units in level L

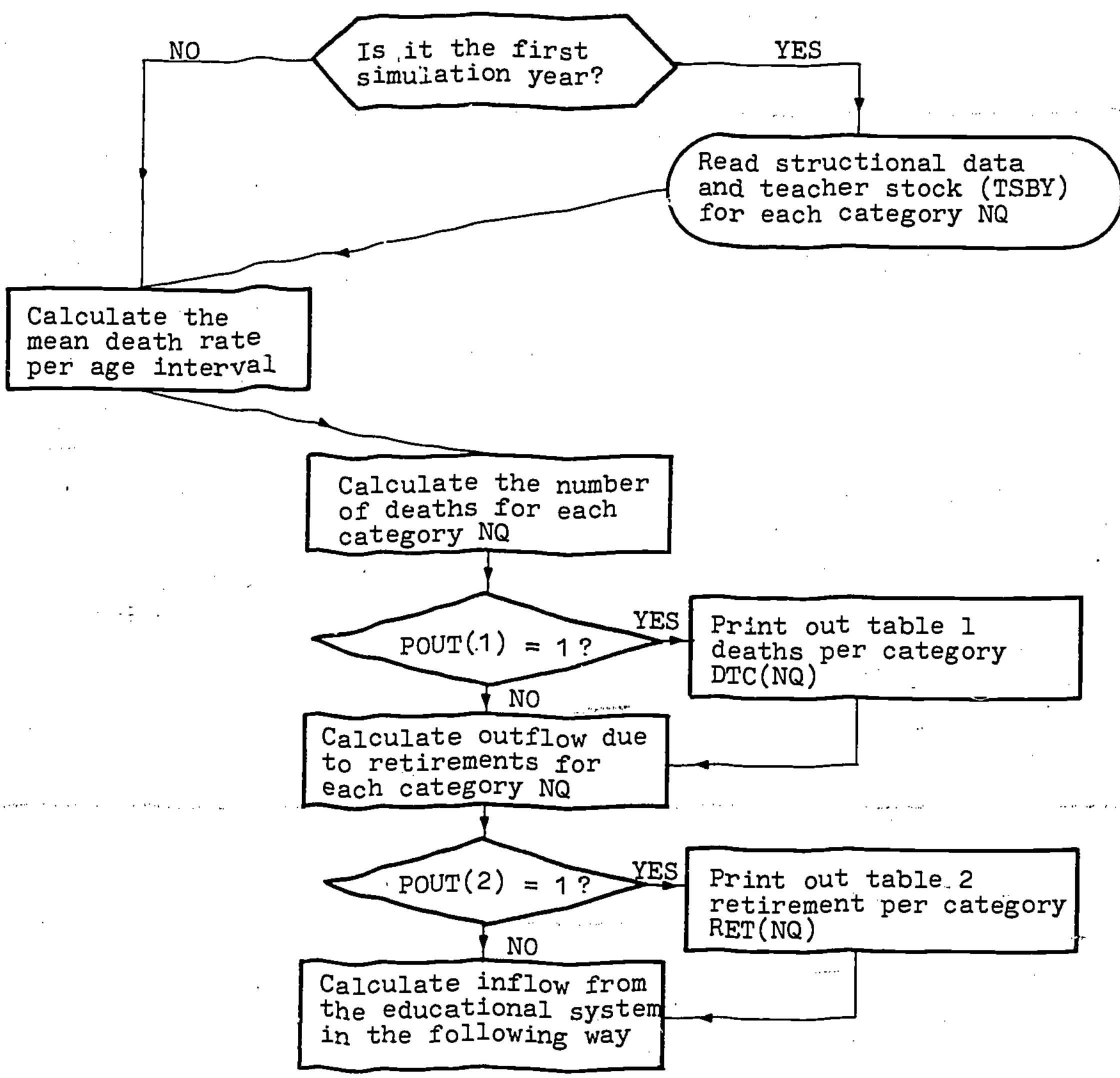
NMLF : Number of levels in the educational system

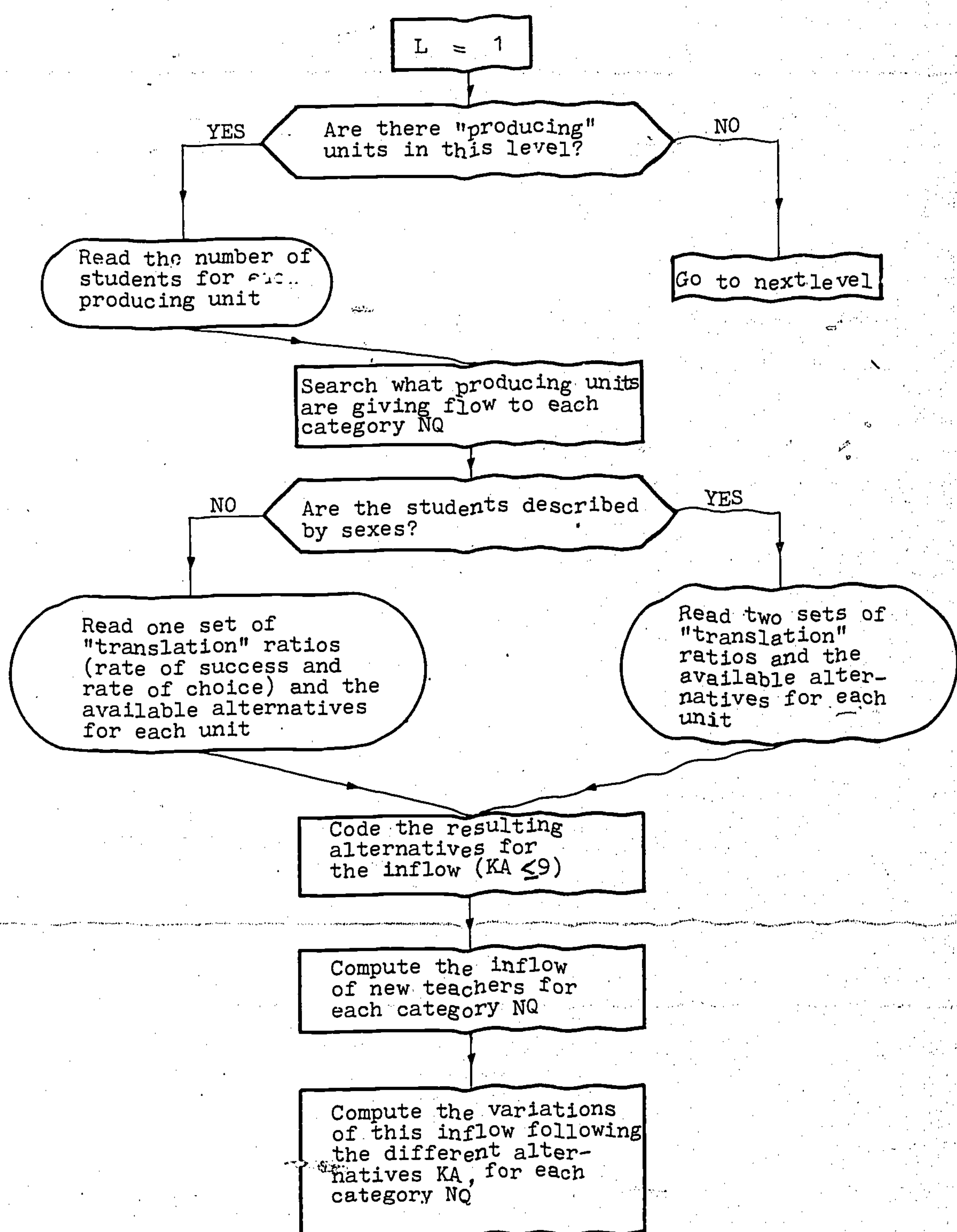
NSG : Number of student groups

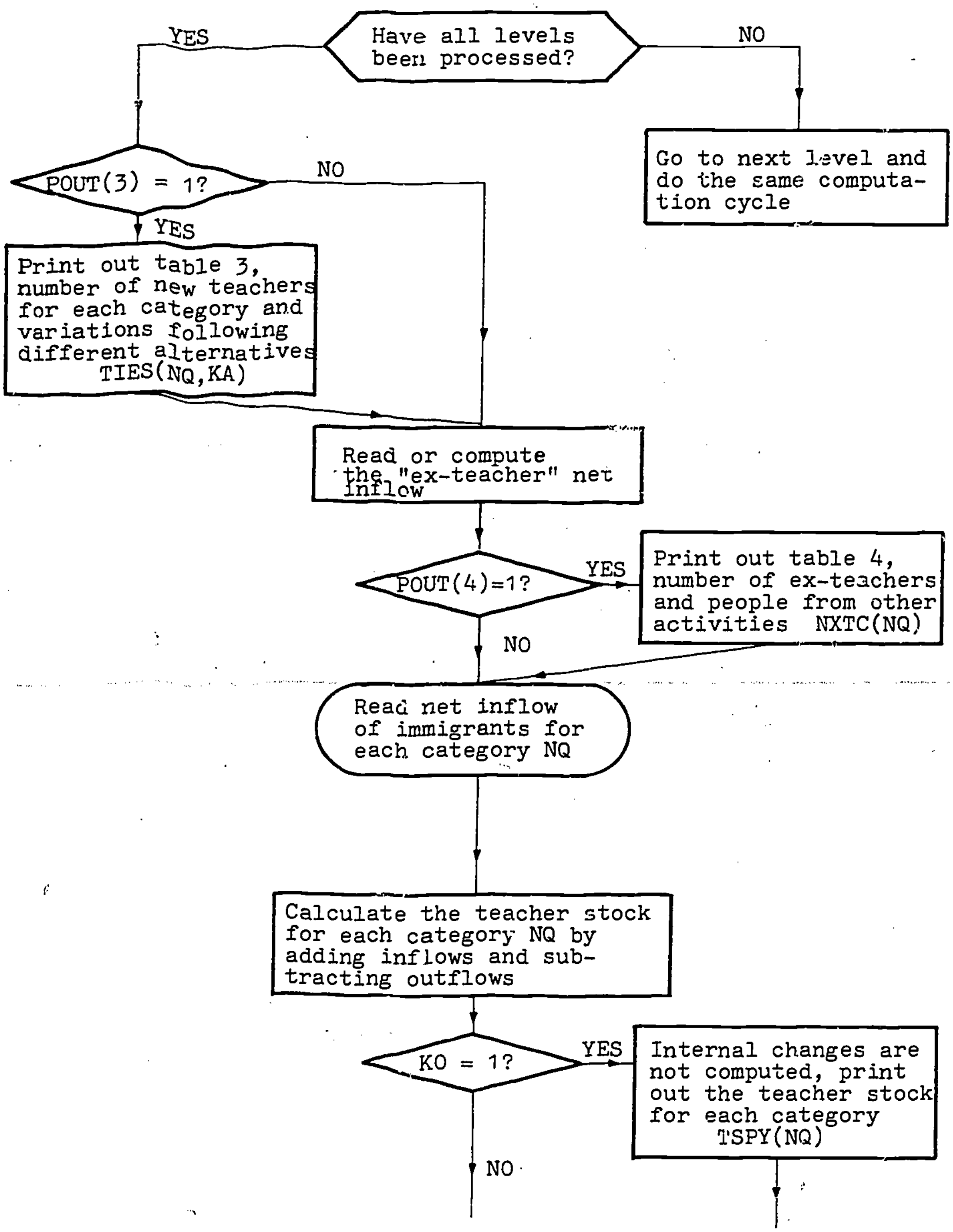
TEACHER SUPPLY SUBMODEL

Computer Flowchart

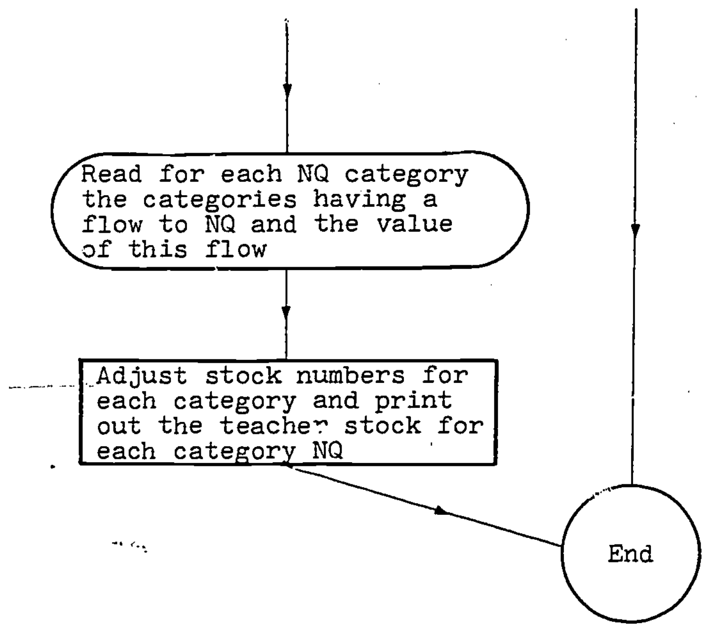
In this flowchart, POUT(I) is a printing vector where POUT(I) = 1 when table I is printed out.




L = 1
Are there "producing" units in this level?
YES
NO
Read the number of students for each producing unit
Go to next level
Search what producing units are giving flow to each category NQ
Are the students described by sexes?
NO
YES
Read one set of "translation" ratios (rate of success and rate of choice) and the available alternatives for each unit
Read two sets of "translation" ratios and the available alternatives for each unit
Code the resulting alternatives for the inflow (KA ≤9)
Compute the inflow of new teachers for each category NQ
Compute the variations of this inflow following the different alternatives KA, for each category NQ



Have all levels been processed?
YES
NO
Go to next level and do the same computation cycle
POUT(3) = 1?
NO
YES
Print out table 3, number of new teachers for each category and variations following different alternatives TIES(NQ,KA)
Read or compute the "ex-teacher" net inflow
POUT(4)=1?
YES
Print out table 4, number of ex-teachers and people from other activities NXTC(NQ)
NO
Read net inflow of immigrants for each category NQ
Calculate the teacher stock for each category NQ by adding inflows and subtracting outflows
KO = 1?
YES
Internal changes are not computed, print out the teacher stock for each category TSPY(NQ)
NO


Read for each NQ category the categories having a flow to NQ and the value of this flow
Adjust stock numbers for each category and print out the teacher stock for each category NQ
End

Appendix 4

TEACHER COMPARISON SUBMODEL

1. Objectives

For each simulation year this submodel will compare the teacher supply stock, calculated by the Teacher Supply submodel, and the stock of teachers required as calculated in the Resource submodel, in order to show where unbalances occur. This book-keeping operation is straightforward, and the interesting part consists of designing policy alternatives in order to cancel or minimise unbalances for each level and qualification group. The achievement of this goal is here only investigated within a set of restrictive assumptions. This submodel does not define all the policy decisions which could be taken when facing a manpower structure different from the one desired; it only indicates certain short-term adjustment possibilities.

2. Policy Variables

There are two possible approaches to solving the problem of minimising unbalances. The demand approach consists of changing demand parameters in order to adjust the requirement to the available supply. The problem then falls into the choice and definition of policy variables which could be, for example: class size, teaching load, length of curricula, substitution of qualification groups, etc.

The model assumes that two parameters only are accessible to policy decision: class size and teaching load (weekly hours). The increase for each parameter is upper bounded (limitation of resources and labour). The model is built so as to show roughly how educational parameters would react to unbalances created by a supply which is, most of the time, far from being adapted to requirements. These changes will not influence educational parameters for the following year's requirements.

The supply approach consists of varying the supply stock, i.e. by changing its inflows. The conception of this simulation model does not allow a direct description of policies such as speeding up the return of women teachers into teaching, mainly because these policies do not entirely fall within the realm of educational planning. The only possibility which is dealt with is short-term adjustments, i.e. inflow alternatives without time lag. For this reason sensitivity analysis has been embedded in the Teacher Supply model, the inflow of graduates into the teaching profession is changed by acting on the rate of success and the rate of choice. These rates are assumed to be parameters sensitive to policy decision. The supply alternatives produced by the Teacher Supply submodel can be used to overcome or minimise unbalances that remain when certain adjustments of demand parameters have been carried out.

3. Method

The method employed is only a trial which outlines the likely results for a limited number of parameters of a situation where supply and demand for teachers are faced and adjusted. For this adjustment a priority has been established between the parameters, this, of course, giving us an implicit preference function. It is assumed that when there is an unbalance, the parameter class size (number of students in each class) is used first, i.e. before the parameter teaching load. This order is chosen for two main reasons: class size changes can influence several teacher categories simultaneously and is therefore an unsuitable parameter for the final adjustment. The second reason assumes that authorities are likely to use first the less expensive resources. The relationship upon which the computations are based is obtained in the following way:

If LEVELT(Q) is the number of teachers of qualification Q required in a given level, we have the following expression:

$$\text{LEVELT}(Q) = \sum_{I,J} \frac{\text{NMT}(I) \cdot \text{WHC}(J)}{\text{CLS}(I) \cdot \text{WHT}(Q)} \qquad (1)$$

Where:

NMT(I) - number of students in unit I

CLS(I) - class size for unit I

WHT(Q) - weekly hours of teaching for teacher qualification Q

WHC(J) - weekly hours of curricula J which requires a teacher with qualification Q

Let us call:

- x the rate of increase/decrease for all class sizes of all units of the level
- y the rate of increase of weekly hours of teaching
- z will be the resulting rate of change for the required number of teachers with qualification Q

(1) becomes:

$$(1+z)\ \text{LEVELT}(Q) = \sum_{I,J} \frac{\text{NMT}(I) \cdot \text{WHC}(J)}{(1+x)\text{CLS}(I) \cdot (1+y)\text{WHT}(Q)} \qquad (2)$$

The division (1)/(2) yields:

$$(1+z)(1+x)(1+y) = 1$$

This simple relation gives the possibility of computing the relative changes needed for class size and weekly hours of teaching without using the actual value of each parameter. It has to be noted that any change in class size will change the value of teachers' requirements for all qualifications used inside a level; on the other hand, any change in weekly hours of teaching will affect only one qualification group.

4. Procedure

The classification principles used for defining teacher categories in the Teacher Supply submodel and the Resource submodel may or may not be the same. If they are different a translation has to be made before the supply of teachers can be compared with the demand. Data for such a translation are inputs to the Teacher Comparison submodel. The calculations in this submodel are organised as outlined below:

(1) Test if the classification principle used to define requirements for teachers is identical to the one used by the Teacher Supply submodel. If the classifications are not identical, proceed to a reaggregation in order to reach a unique classification for both stocks.

(2) Compute the distribtuion of the teacher supply belonging to each Q-group between the different levels of the educational system. The distribution of teacher supply for each level is assumed to be done proportionally to the calculated requirements for each level.

(3) Compute unbalances for each level and Q-group by subtracting requirements from supply stocks. The results are printed out.

(4) Balancing policies for each level:

Compute, for the level which is being dealt with, the mean unbalance.

- If it is equal to zero, go to (c).
- If it is not, go to (a) or (b).

(a) Compute for each level, and when there is an overdemand, the rate of increase for class size; once all qualification groups (Q-group) have been dealt with, choose the minimum rate which will be applied to all units of the level. Continue to (c).

(b) In case of general oversupply for the level, class size will be reduced. The policy employed will overcome the minimum oversupply which occurs within the level. The rate of decrease for class size is then applied to all units of the level. If this operation is processed, go to (c).

(c) Compute for each Q-group the rate of increase for the weekly teaching load in case of overdemand. If there is an oversupply for this Q-group, the weekly teaching load will remain unchanged or reduced depending on the limits of change which have been read as inputs. The remaining unbalances and the sequence of rates of change for different Q-groups will be printed out.

This computation cycle is carried out for all levels.

(5) Balancing policies for each Q-group:

Once the previous computations have been done, the remaining unbalances are aggregated for each Q-group and printed out. If there exist supply alternatives, step 5 is then processed.

If there is not any supply alternative available, the computations are terminated.

If the remaining unbalance does not lie within an acceptance interval, teacher supply alternatives are used.

Two main policies can be applied, one for oversupply and the other for overdemand. The result of such a policy will be within a certain interval due to the uncertainty or possible interval of change attached to the rate of choice (going into the teaching profession). These policies are assumed to be hypothetical, so their results do not update the teacher supply stock.

5. Definition of Inputs

Most of the inputs used by the Teacher Comparison submodel are produced by the Resource and the Teacher Supply submodels. The data needed are in relation to the constraints which bind the use of the so-called resources, class size and weekly teaching load. Some other information may be required in order to reach identical categories for both available teachers and required teachers.

Base Year Inputs

NGR : Number of couple of categories which are equivalent in the new classification

NGR = 0 if teacher supply and teacher demand categories are equivalent

M : M(I) for I = 1,NGR is the reference demand category code number which should be kept in the new classification

P1 : P1(I) for I = 1,NGR is the code number of a supply category which is equivalent to M(I) and which will be called M(I) in the new classification

XMAX: Is the maximum rate of increase for any class size

XINF: Is the maximum rate of decrease for any class size

YMAX: Is the maximum rate of increase for any teaching load

YINF: Is the maximum rate of decrease for any teaching load

Yearly Inputs

- From Resource submodel:

NTEACH : NTEACH(NQ) NQ = 1,MAXNQ number of required teachers for each category NQ

LEVELT : LEVELT(L,NQ) number of required teachers for each category NQ and level L

- From Teacher Supply submodel:

TSPY : TSPY(NQ) number of available teachers for each category NQ

TIES : TIES(NQ,KA) KA = 2,9 variations of the teacher supply stock for each category NQ and alternative KA

Internal Notations

TSPYL : TSPYL(L,NQ) number of available teachers for each category NQ and level L

DELTA : DELTA(NQ) unbalance for category NQ inside a given level

DELTAT : DELTAT(NQ) total unbalance for all levels related to category NQ

DELTAS : DELTAS(L) unbalance of teachers for each level L

A positive unbalance means an oversupply, a negative one an overdemand.

For both L and NQ:

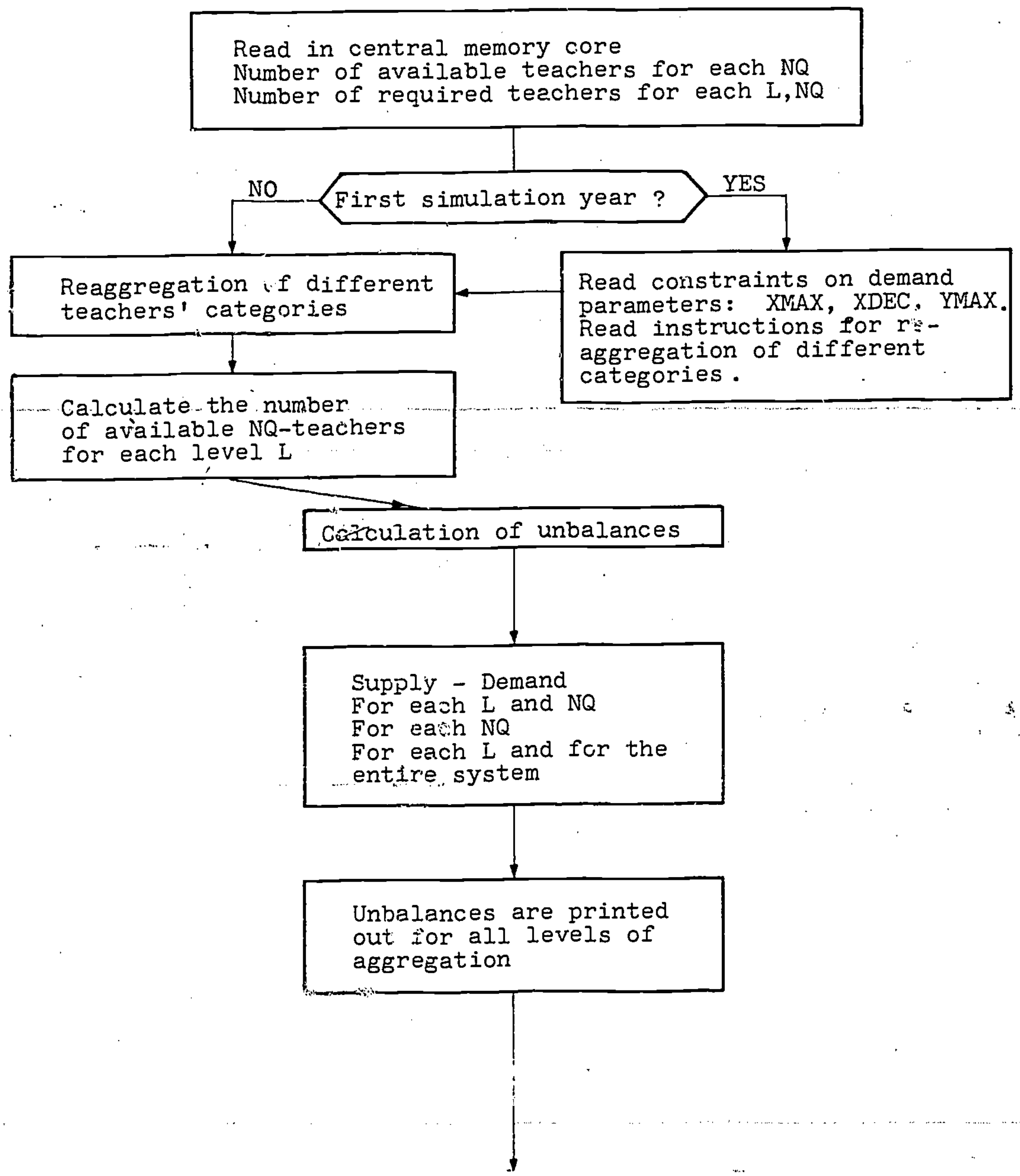
Z : rate of change for the number of teachers required in order to overcome the disequilibrium between supply and demand in category NQ

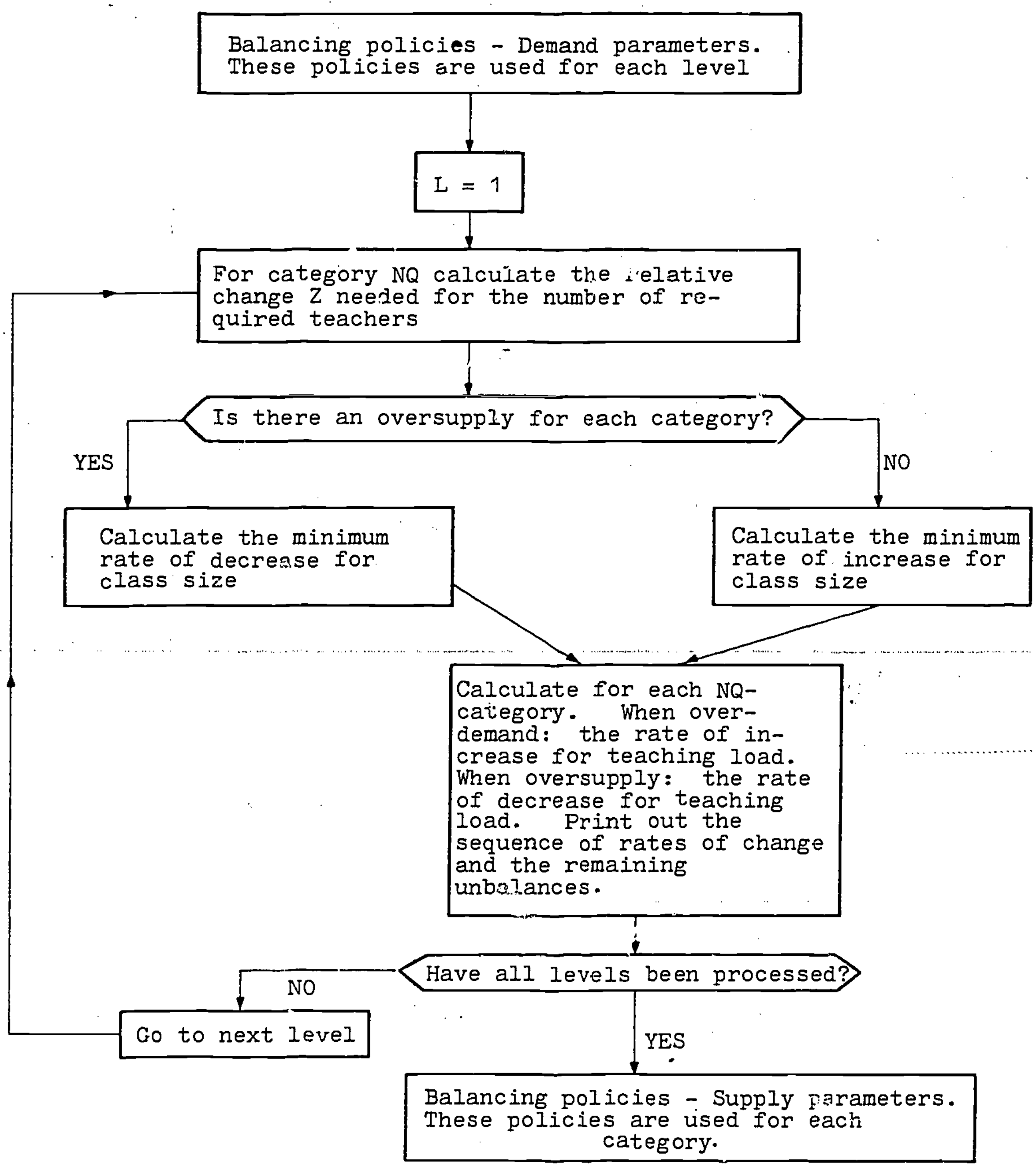
X : rate of increase/decrease for all class sizes of all units of the level L

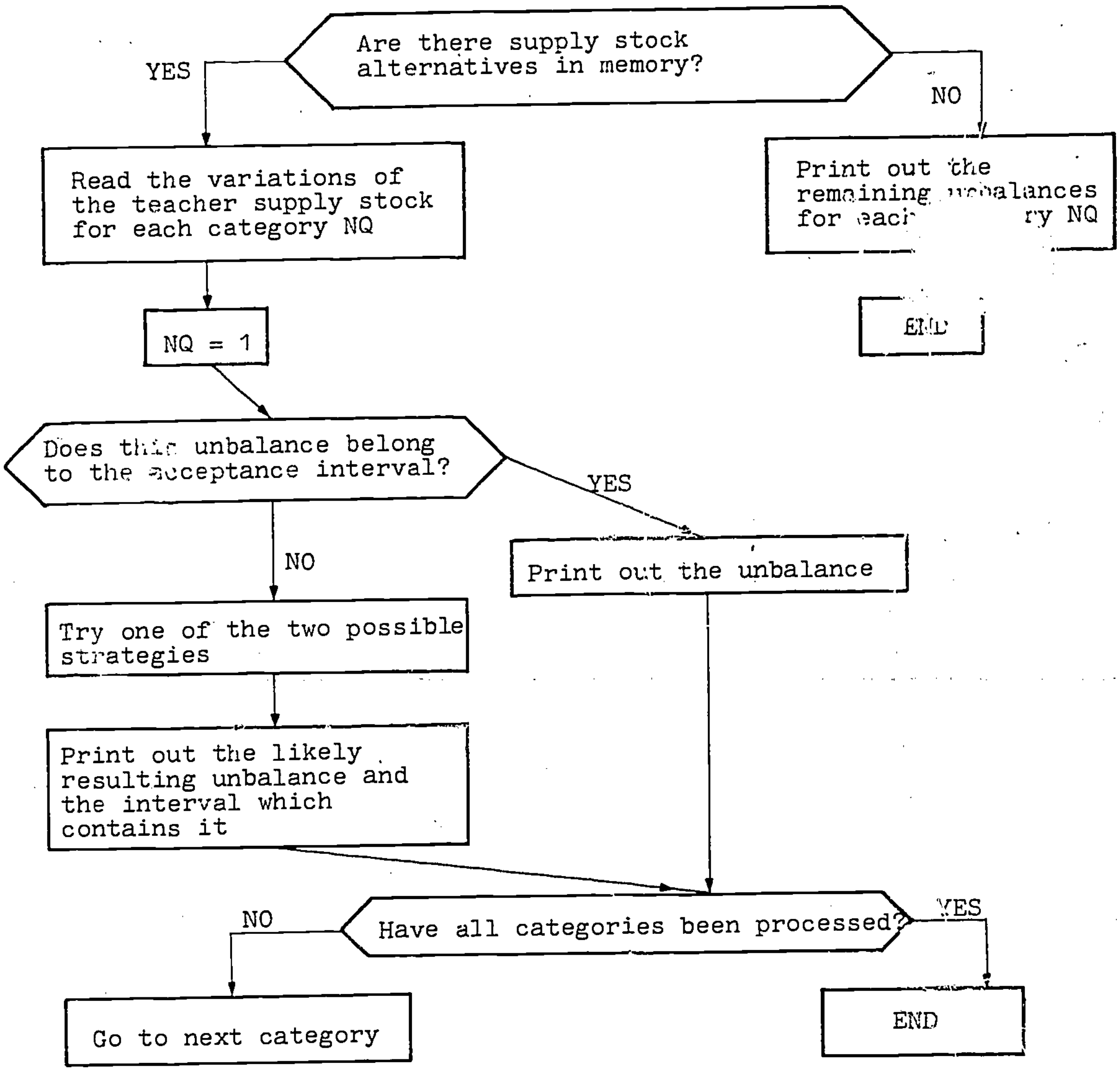
Y : rate of increase/decrease for the teaching load of teachers category NQ

TEACHER COMPARISON SUBMODEL

Computer Flowchart




Balancing policies - Demand parameters. These policies are used for each level
L = 1
For category NQ calculate the relative change Z needed for the number of required teachers
Is there an oversupply for each category?
YES
NO
Calculate the minimum rate of decrease for class size
Calculate the minimum rate of increase for class size
Calculate for each NQ-category. When over-demand: the rate of increase for teaching load. When oversupply: the rate of decrease for teaching load. Print out the sequence of rates of change and the remaining unbalances.
Have all levels been processed?
NO
Go to next level
YES
Balancing policies - Supply parameters. These policies are used for each category.


Are there supply stock alternatives in memory?
YES
NO
Read the variations of the teacher supply stock for each category NQ
Print out the remaining unbalances for each category NQ
END
NQ = 1
Does this unbalance belong to the acceptance interval?
YES
NO
Print out the unbalance
Try one of the two possible strategies
Print out the likely resulting unbalance and the interval which contains it
NO
Have all categories been processed?
YES
Go to next category
END

Appendix 5

A BRITISH CASE STUDY

As mentioned in the main text, our study deals with the raising of the school-leaving age from 15 to 16. Different policy alternatives for the time schedule for the introduction of this reform have been investigated, i.e. three different starting years, alternative 2 (= 1970), 3 (= 1971) and 4 (= 1972), have been combined with three different introduction rates, A, B and C.

The study covers England and Wales, and includes primary schools (treated as one "branch") and secondary schools, which are split into six different "branches". The university level, teacher-training colleges, special institutions (for instance for handicapped children) and nursery schools are not included.

Structural description and general input data

The simulated part of the school system is divided into three levels. The first level comprises primary school; the second level, the first four forms of secondary school; the third level, the last three forms of secondary school.

The school year 1966/67 has been chosen as the base year, i.e. the starting year of the simulation, as it was the most recent year for which sufficient statistics were available. Figure 1 illustrates how the structure of the school system has been described, i.e. the partition into levels, branches and units, and also gives, for each unit, the pupil stock for the base year. Some explanatory comments on the chosen structure are necessary.

First, comprehensive schools are not shown as a separate group; pupil stocks in these schools have therefore been distributed between maintained secondary modern schools and maintained grammar and technical schools, in proportion to the present school population in these two latter types of school. The main reason for this distribution was to avoid the incidence of the changing structure of secondary education. This change seems to be mainly of an organisational nature, where different pupil categories are going to be taught together in one type of school (comprehensive school) rather than in different types, such as modern and grammar schools. As the composition of the teacher stock (graduate - non-graduate teachers) is very different in modern and grammar schools, this way of redistributing the pupil stock in comprehensive schools could produce more or less biased projections for teacher requirements, if our assumption of proportionality deviated substantially from reality.

Secondly, it will be noticed that more than one unit is needed to simulate the first class of primary school and that the base year stock for this class is relatively high.

Primary school comprises six classes. According to the present rules, a child has to be five years old before he starts in the first class. Within the school year, there are three points in time at which a child can enter school; the beginning of September, the beginning of January, and the beginning of April. We have assumed that those who start in September in year t were born between 2nd April in year t-5 and 1st September in year t-5; those who start in January in year t+1, between 2nd September in year t-5 and 1st January in year t-4; and those who start in April in year t+1, between 2nd January in year t-4 and 1st April in year t-4.

Since it is only possible to go from one class to the next at one point in time, this implies that the number of first class pupils in primary schools increases over the school year, reaching its peak in the last term. These rules imply that those who start in January and April will have to spend more than six years in primary school. This explains the relatively large base year stock in the first class of primary school, and why we need more than one unit to simulate this class. A graph showing the pupil flow from the first to the second class will be useful (see Figure 2).

The base year stocks given in Figure 1 are estimates. The available statistics do not give stocks by class, but only total school population in each type of school and the age distribution of the pupils by type of school (Table 5 in ref. 1).

This information was the basis for our estimation of the distribution of pupils by class, or year in school, in the different kinds of schools. Since the age of pupils is essential to our problem, it would have been easier to operate with age groups rather than years in school. This, however, was not possible, as available teacher and class size data relate to years in school and not to age groups of pupils.

In our estimates of pupil stocks in different classes or years in school, we assume that the births are evenly distributed throughout the year. This together with a strict application of the rule that a child cannot start school before he is five years old and the assumption that no one repeats during compulsory schooling, enables us to estimate pupil stocks in all classes or years in school up to (and including) the fourth class of secondary school. Pupil stocks in the sixth and seventh year are given in Table 9 of ref. 1. Pupil stocks in the fifth year are then rest determined. If the assumptions made in converting from age groups to classes are correct, then the fourth year of secondary school is the last compulsory year.

Our assumptions in conjunction with the present rules imply that a pupil is allowed to leave school (fourth year of secondary) either in April or at the end of the school year, depending on his date of birth. We assume, however, that all leavers leave at the end of the school year. The rise in school-leaving age then implies that the fifth year of secondary school becomes compulsory.

In the study, migrations have not been taken into consideration, and it is assumed that all entrants to the system go through the first class of primary school.

For enrolment figures, see Table 1.

Concerning the transition coefficients, we first estimated pupil stocks by class in school years 1965/66 (Table 5, ref. 2), and 1966/67 in the way described above. The stocks arrived at in this manner constituted the basis for our estimation of the transition coefficients. It is assumed that no-one drops out, leaves or repeats in the compulsory part of the system.

For the three upper forms or years in secondary school, no attempt has been made to distinguish between drop-outs and leavers. Everybody who leaves or drops out is assumed to leave at the end of the school year.

Transition coefficients change over time in level 3, because of the tendency towards staying on longer at school. Information concerning the trends in transition coefficients (Table 7, ref. 1) is presented in Table 2.

Input data concerning teachers

The proper method for projecting teacher requirements would, of course, be to establish the connection between subjects and the kind of teachers that should ideally be teaching them. Although this is fully possible within the framework of SOM, we do not distinguish between different subjects, but treat all subjects taken in a given class as one subject.

Neither was any attempt made to establish the ideal relationship between type of teacher and type of subject. In our study, we only distinguished between graduate and non-graduate teachers, and assumed that the existing proportion between these two categories will remain unchanged.

For primary schools, however, data were available only for the proportion of graduate and non-graduate teachers and for all years together, and not for each separate year. Even if this composition of the teacher stock within primary school as a whole is considered desirable, our assumption implies that our teacher requirement projections for the two teacher categories taken separately may be more or less biased, as the requirements may depend on the distribution of pupils among different units, and this distribution varies over time.

"Teaching obligations", x (number of periods taught per week) were estimated on the basis of the pupil/teacher ratio, $\frac{S}{T}$, and average class size, ACS, as given in Table 1, ref. 1.

$$x = \frac{S}{T} \; \frac{\text{Duration of school week (periods)}}{\text{ACS}}$$

Duration of school week was set arbitrarily at 30 periods, producing "teaching obligations" of 26.8 periods per week. It should be noted that the somewhat arbitrary setting of duration of school week is of no importance to the results, since it is only the ratio $\frac{\text{Duration of school week}}{\text{Teaching obligations}}$ that matters, but they are read separately as inputs.

The same procedure could have been followed for all secondary schools, but here information on teaching obligations was available (Tables 3 and 9, ref. 3). This information was given in minutes, but by assuming that the average period was 40 minutes, these data were converted to average teaching obligations per teacher (See column 5, Table 3). The number of weekly periods supervised by a teacher was set at 37.5 in lower secondary school, and 30 in higher secondary school. Teaching obligations were assumed to be the same for graduate and non-graduate teachers within a given type of school.

However, calculations based on these assumptions gave a considerably larger number of required secondary school teachers in the base year than the existing stock. This difference was assumed to be due mainly to statistical uncertainties and local variations in weekly periods and weekly teaching obligations. The data were therefore adjusted (see numbers in brackets, Table 3) so that the difference in the calculated and actual teacher stock in the base year was eliminated.

It should be stressed that estimates of the distribution of teachers among graduates and non-graduates only reflect the teaching situation in the base year, and need not be considered as optimal. If the situation in 1966/67 was a "disequilibrium" situation, we will run, of course, the risk of projecting a disequilibrium situation into the future.

Input data for space requirements

Information on space requirements and construction costs was obtained from the Architects and Building Branch of the Department of Education and Science in London. This information was not given in a form completely suitable for our purpose. The number of square feet per pupil (minimum standards) is dependent upon the size of the school, square feet per pupil being a decreasing function of school size. To avoid this difficulty, it was assumed that new schools will, on average, be of the same size as the average school in the old school population (Table 4, ref. 1). These estimates are given in column 6, Table 3. Information on building costs was given as cost per pupil place. Using the estimated number of square feet per pupil, we can convert into cost per square foot. (See Table 3.)

Calculated results

For detailed results referring to category of school or even a given year within a school, the reader is referred to the computer outprints.

The computer outprints contain the following tables printed out for each year:

(1) Pupil stocks by level and unit.

(2) Total number of teachers needed by level and unit.

(3) Total teaching accommodation (area) needed by level and unit.

(4) Required investments in area in comparison with the base year.

(5) Capital cost.

(6) Total number of teachers needed by category and level.

In the computer outprints, the notation "block" is used. Levels 2 and 3 have been divided into 5 blocks each. The blocks consist of the following.

Level 2

Block 1: The first four forms of maintained secondary modern schools.

Block 2: The first four forms of maintained grammar and technical schools.

Block 3: The first four forms of all other maintained secondary schools.

Block 4: The first four forms of direct grant schools (grammar-upper).

Block 5: The first four forms of independent schools recognised as efficient and other independent secondary schools.

Level 3

Block 1: The last three forms of maintained secondary modern schools.

Block 2: The last three forms of maintained grammar and technical schools.

Block 3: The last three forms of all other maintained secondary schools.

Block 4: The last three forms of direct grant schools (grammar-upper).

Block 5: The last three forms of independent schools recognised as efficient and other independent secondary schools.

For each block, the computer outprints contain the following information.

(1) Additional square feet needed.

(2) Additional number of rooms needed.

(3) Monetary area investments.

It is, of course, quite impossible to comment on all these results. We shall therefore confine ourselves to the most important ones.

Pupil stocks

The projections are given in Tables 4 and 5 for primary and secondary schools respectively. The results are given for all secondary schools taken together. These projections are, of course, more reliable than the ones relating to type of school.

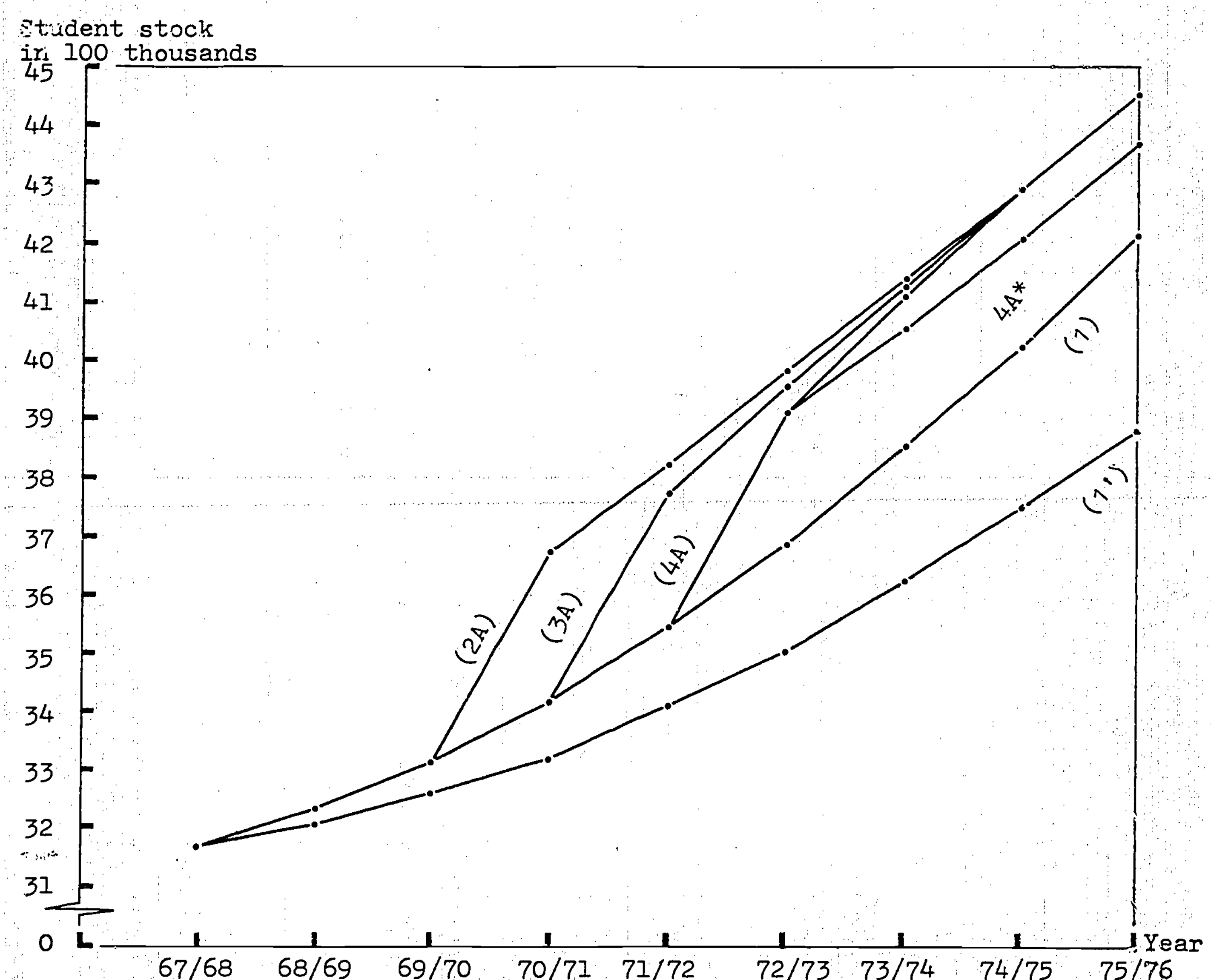
A few comments on Table 5 might be useful.

The first two columns are included only for reference. Column 1' shows how student stocks might be expected to develop if there were no rise in school-leaving age and no tendency towards staying on longer at school. Column 1 shows the expected development if no rise takes place and if the tendency to stay on longer in school increases according to the rates given in Table 2. By comparing any of the other columns with these two, one can easily see how much of the difference in pupil stocks between two points in time is due to the tendency towards staying on longer in school, and how much is due to the rise in school-leaving age.

To give a better picture of how the results vary with the actual point in time at which the rise is carried through, a graph might be useful. We compare 1, 1', 2A, 3A, 4A and 4A*. As will be remembered, the A alternatives are those where the rise is carried out in one step. Pupils who have been "forced" by the reform to stay on one year longer have been assumed to adopt the continuation pattern of those who stayed on voluntarily to the age of 16 before the reform. The influence on the results of this assumption can be seen by comparing cases 4A and 4A*. 4A* is identical to 4A, except that it is based on the assumption that those who have been forced to stay on one year longer leave school immediately after this year.

Given that the school leaving age is going to be raised, it is clear from both Table 5 and Figure A, that it is only in some intermediate years that pupil stocks will vary between the different policy alternatives (as long as the assumption as to pupil behaviour is the same). It can be seen from the figure that the curves 2A, 3A and 4A will meet in the school year 1975/76.

Fig. A: Development of student stocks in secondary school according to the alternatives 1, 1', 2A, 3A, 4A and 4A*.



Curve 1 is the projected development with no rise in compulsory schooling nor any other policy changes influencing present trends. However, the difference between curves 1 and 2A, 3A or 4A cannot be wholly accounted for by the pupils forced to stay at school. This is so because, during the year they are forced to stay at school, they have been assumed to adopt the continuation pattern of those who stayed on voluntarily; this means that some of those who, originally, were forced to stay on, later have been assumed to go on voluntarily. In the first year after the rise, however, the discrepancy between curve 1 and the A curves can be accounted for by the pupils forced to stay on.

In the case of curve 4A*, the whole difference between this curve and curve 1 should be interpreted in this way.

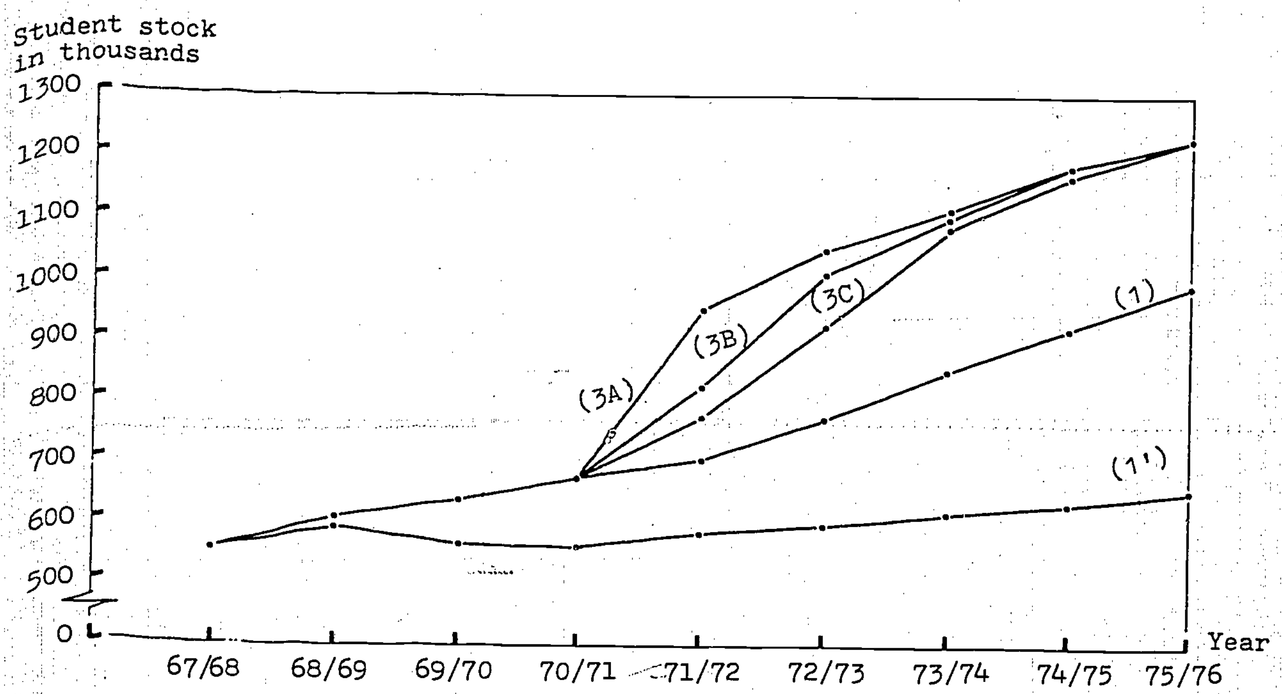
We now turn to the case where the school-leaving age starts increasing at the same point in time, but with a choice as to whether it should be increased in one, two or three steps. The results for pupil stocks can be seen in Table 5. A graph might again be useful here. We now concentrate on alternative 3, where the school-leaving age starts increasing between school year 1970/71 and 1971/72. (See Figure B.)

This figure refers only to pupil stocks in the three higher forms of secondary, while Figure A referred to secondary school as a whole. Only the pupil stocks in these three forms are influenced by the decision, and it is also only these forms that undergo changes due to trends in transition coefficients.

This graph seems to give a good explanation of the original desire to raise the school-leaving age in 1970. This can be seen from curve 1', which has a minimum in 1970/71. On the other hand, Figure A (relating to secondary schools as a whole) does not show such a minimum. This is due to the fact that the increase in pupil stocks in the first four forms of secondary schools more than outweighs the decrease in the three upper forms. If trends in transition coefficients are taken into account (see curve 1), such a minimum does not appear for the three upper forms either.

Hitherto, we have concentrated only on what might be expected to happen to pupil stocks as a consequence of the raising of school-leaving age. We have seen that, regardless of when and how (within the limits of our alternatives 2, 3 and 4) the rise is carried through, the stock of pupils in the simulated part of the school system will be the same in 1975/76. The longer the rise is postponed the more the steps in which it is to be carried through, the greater the number of pupils receiving less education. The obvious conclusion is, therefore, that the stronger the wish of decision makers to speed up the pace of educational development the sooner the rise should be carried through and in as few steps as possible. But, due attention must, of course, be paid to the possibilities of providing enough teachers and teaching accommodation.

Fig. B: Development of student stocks in the three upper years of secondary school.



Teacher requirements

The calculated results for teacher requirements are presented in Tables 6, 7 and 8. Table 6 relates to teacher requirements within the simulated system as a whole, Table 7 relates to teacher stocks in primary and the first four forms of secondary school, and Table 8 relates to teacher stocks in the last three forms of secondary school.

It is easily seen from Table 6 that, in the end (year 1975/76), the required teacher stock will be the same irrespective of when the change is carried through. The different policy alternatives only imply different ways of building up these stocks.

The same applies to the results in Table 8, except that alternative 4C shows slightly lower "teacher requirements" in 1975/76 than the other alternatives; this is because the full effect of the rise in this case is reached in 1976/77.

The reason for the different growth rates of graduate and non-graduate teachers (Table 5) is, of course, that different parts of the system with different teacher mixes in the base year do not move a pace.

Table 5 shows that the need for non-graduate teachers increases considerably in the year the school-leaving age is raised. This is due to the fact that most of the increased teaching load caused by the rise in the school-leaving age falls on the fifth form of modern schools where, according to Table 3, 81.3% of the teachers are non-graduates.

There is a general uncertainty about the absolute values of the projected number of teachers, due to the uncertainty (cf. p.97) of the input data (weekly periods and weekly teaching obligations) that determine the pupil/teacher ratio. This uncertainty affects, however, the different alternatives in a similar way, and should not, therefore, directly influence the comparison between them.

The increase in teacher requirements caused by the reform is probably biased somewhat upwards. As can be seen from Table 3, class sizes are remarkably low in the three upper forms of secondary (they are assumed to be unchanged during the simulation period). This applies especially to modern schools (units 7, 8 and 19 in the third level), on which most of the burden of the rise will fall. A possible explanation is that classes are not put together, even when the class size diminishes considerably, and/or that schools are too small to be able to take advantage of such an amalgamation. The under-utilisation of resources implied by these low class sizes will diminish automatically when the school-leaving age is raised.

Investments

Lastly, let us look at the "investment requirements" in school buildings according to the different alternatives. The investments are defined here as the increase in capital cost for space requirements from one year to the next. The "investment requirements" are given for the whole simulated system and, at each level, for each year of the simulation period (see Table 9).

As can be seen, the total investments necessary over the whole simulation period are the same for the policy alternatives 2A, 2B, 2C, 3A, 3B and 4A, and slightly smaller for 3C, 4B and 4C. This is because the full effect of the rise in the three last-mentioned cases does not appear within the range of the simulation period. If the simulation period had been extended by two years, the total investments over the whole period would have been the same for all alternatives. It is thus only the distribution of the investments over the years that varies with the different alternatives.

The policy alternative 3 is illustrated in Figure C.

The curves for alternatives 2 and 4 will be similar, except for a one-year negative and positive time lag respectively. Alternative 3A will require an increase in investment in 1970 of about 140% in comparison with 1969.

Curve 1 is included only for reference. This curve shows the interesting and not quite evident result that raising the school-leaving age implies higher investments "today" and lower "tomorrow" in comparison with the reference alternative 1 (where the school-leaving age is not raised).

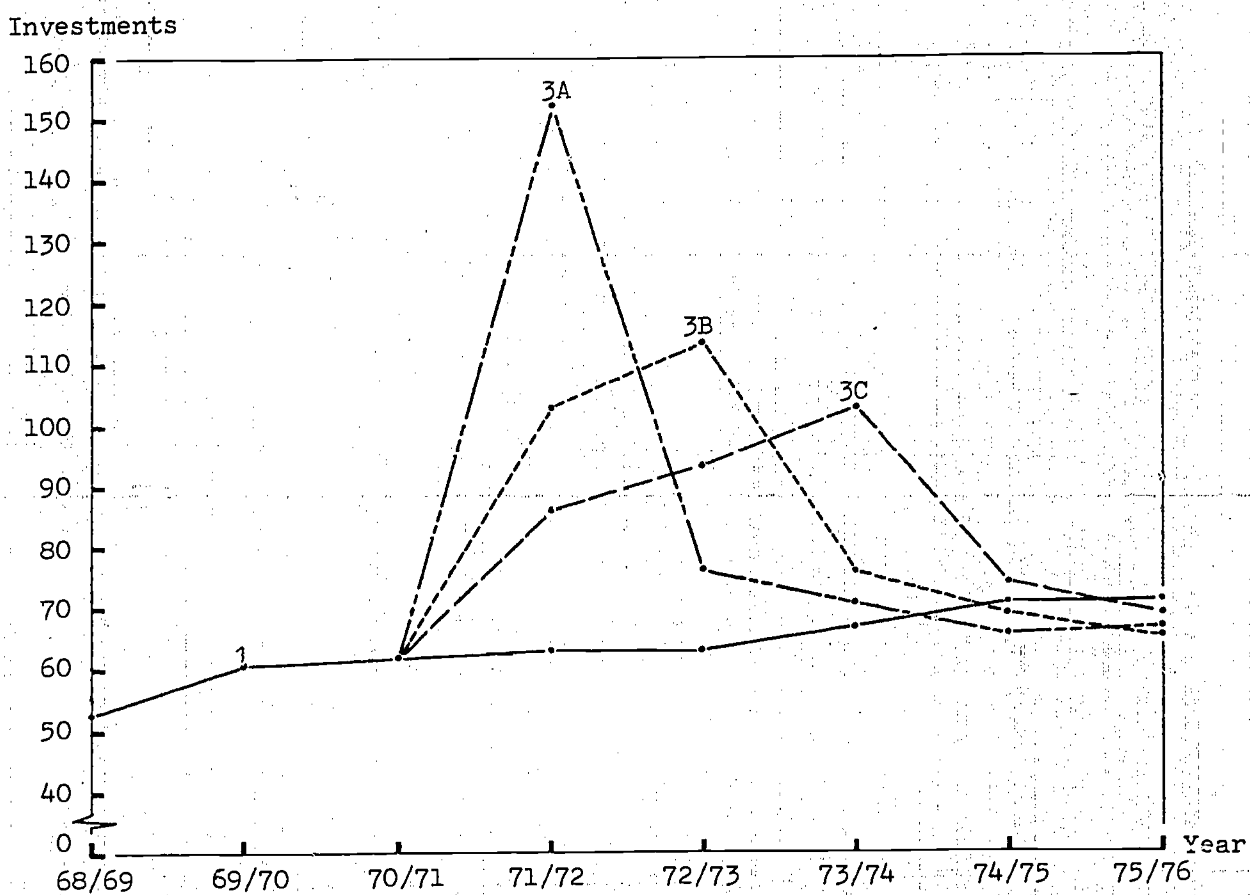
Columns 1 and 2 in Table 9 show respectively the slowing down of the increase in primary school population and the speeding up of the increase in the first four forms of secondary for the simulation period.

The assumption that new schools will, on the average, be of the same size as the old ones is perhaps not justified. For instance, the gradual introduction of comprehensive schools points in the direction of larger schools. This means that our calculated investment requirements may be too high. But this only applies to the absolute value of investments, and not to the relation between different policy alternatives.

Conclusions

Since the decision to raise the school-leaving age is already an accomplished fact, one wants, of course, to put it into effect as soon as possible. But the introduction of the reform will require more teachers and more secondary school

Fig. C: Required yearly investments in primary and secondary school. (Mill pounds).



capacity. Postponing the start of the reform will not, however, facilitate its implementation, as the yearly increase in resource requirements caused by the reform will not diminish. Alternative 2 (start of the reform in 1970) thus seems to be the preferable one. An introduction of the reform in several steps makes the change in resource requirements smoother, which per se is desirable, unless there should happen to be idle capacity in teacher training institutions and in the construction branch. Too many steps, on the other hand, will delay the completion of the reform, which would be against the intention of giving more young people more education as soon as possible. Without a precise criterion of choice, no definite solution can be given, but as a compromise between the original intentions behind the reform and the desire to avoid too severe implementation difficulties, two or three steps can be recommended.

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FIGURES AND TABLES

FIG. 1

THE STRUCTURE OF THE SIMULATED PART OF THE SCHOOL SYSTEM (1)

Primary school (2)

1	Unit no.	1.2.3.4.5.	6.7.8.	9	11	12	13(1)
2	Name of unit	1st year	2nd year	3rd year	4th year	5th year	6th year
3	Base year stock	1,222,800	740,000	714,300	702,400	682,900	654.600

Level 1

Maintained Secondary Modern Schools

1	2	3	4	21(1)	7	8	19
2	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year
3	412,220	411,800	406,600	387,300	122,200	5,400	1,600

Maintained grammar - and technical schools

1	5	6	7	22(2)	9	10	20
2	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year
3	147,400	147,400	148,700	145,900	145,400	89,000	77,900

All other maintained secondary schools

1	8	9	10	23(3)	11	12	21
2	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year
3	43,600	42,900	43,100	41,900	22,000	5,000	3,000

Other independent secondary schools

1	11	12	13	24(4)	13	14	22
2	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year
3	5,600	5,800	6,400	6,400	4,900	2,600	1,400

Direct grant schools (Grammar - Upper)

1	14	15	16	25(5)	15	16	23
2	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year
3	16,100	15,400	15,500	15,400	13,000	11,600	12,100

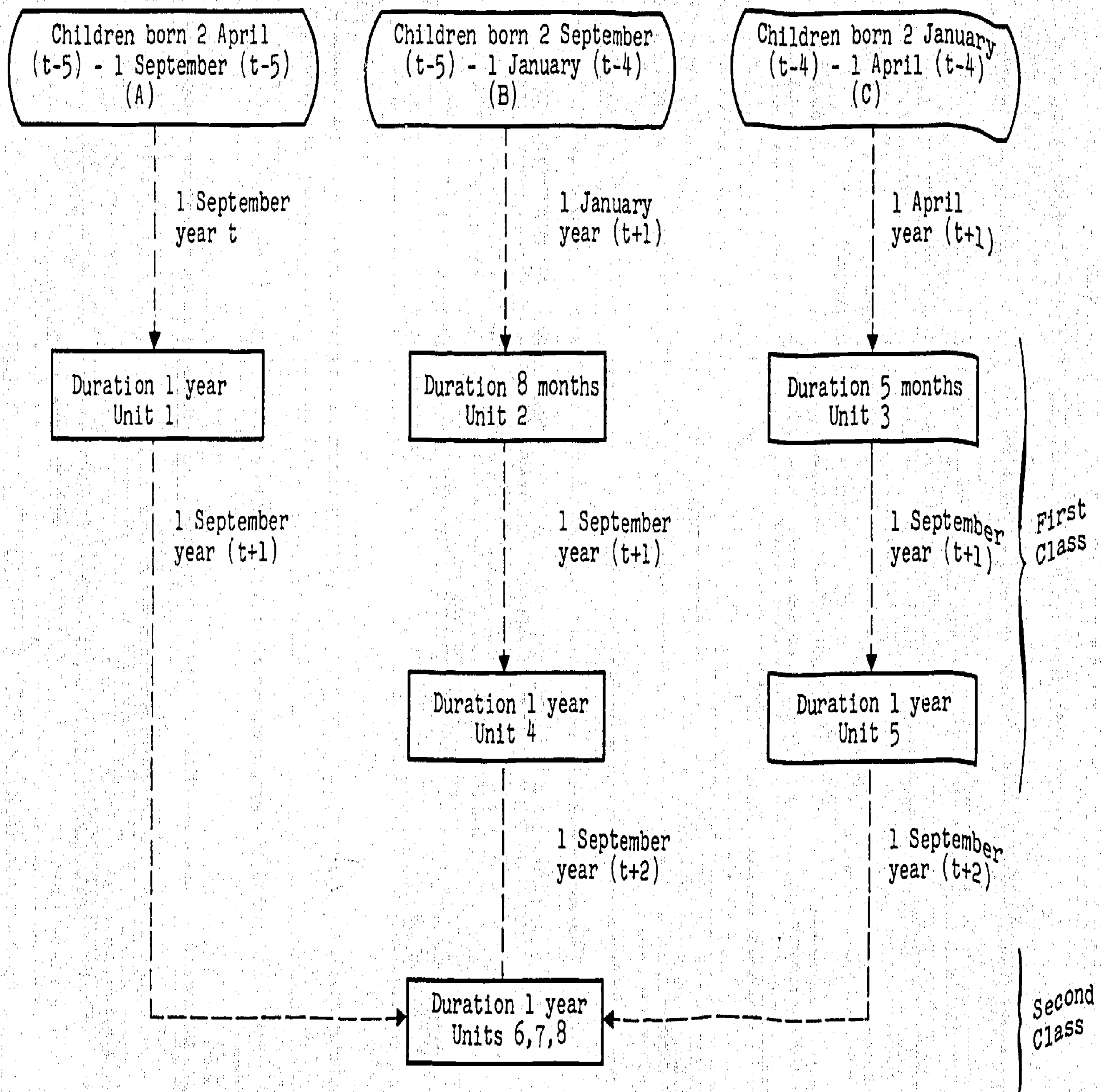
Independent schools recognised as efficient

1	17	18	19	26(6)	17	18	24
2	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year
3	21,300	24,200	29,200	30,000	27,800	19,100	18,000

Level 2   Level 3

(1) Notice that the last units in levels 1 and 2 have got two unit numbers, for explanation see the model description.
(2) Primary school includes both maintained and private schools, all age schools are also included here.

Figure 2: FLOW OF PUPILS FROM 1st TO 2nd YEAR OF PRIMARY SCHOOL



In our computations units (2) and (3) were treated as if they took a whole year; that means that the teacher and space requirements arrived at refer to the peak term of the school year.

TABLE 1

ENROLLMENT FIGURES (1)

YEAR	
67/68	819100
68/69	845500
69/70	848300
70/71	835400
71/72	821200
72/73	813900
73/74	834000
74/75	853000
75/76	869700

(1) The figures are estimated on the basis of information given in /1/, table 41.
Of these numbers a fraction 0.4170 were assumed to enroll in unit (1), 0.3330 in unit (2), and 0.2500 in unit (3). (See figure 2).

TABLE 2

YEARLY INCREASE IN TRANSITION
COEFFICIENTS IN PER CENT (LEVEL 3)

TRANSITION COEFFICIENT [1]	YEARLY INCREASE	EXPLANATORY NOTES
(1.7)	4%	These transition coefficients refer to the transfer from the 4th year to the 5th year of secondary school.
(2.9)	1%	
(3.11)	2%	
(4.13)	1%	
(5.15)	2%	
(6.17)	1%	
(7.8)	2%	Transfer from 5th year to 6th year
(9.10)	2%	
(11.12)	2%	
(13.14)	2%	
(15.16)	1%	
(17.18)	1%	
(8.19)	1%	Transfer from 6th year to 7th year
(10.20)	1%	
(12.21)	1%	
(14.22)	1%	
(16.23)	1%	
(18.24)	1%	

(1) The transition coefficient (ij) describes the proportion of students in unit i year (t - 1) who are in unit j next year. For an explanation of unit number see Fig. 1.

TABLE 3

RESOURCE DATA (1)

	1	2	3	4	5	6	7
Unit N°	Periods per week	Average class size	% of teachers who were non-graduates	% of teachers who were graduates	Number of periods lecturing per teacher	Area per student sq. ft	Cost per sq. ft.
Level 1 (Primary school)							
1-12	30	32.7	100 62.1	0 37.9	26.8	23.6	£8.7
Level 2							
2		26.2	82.3	17.7	20.1 (27.9)		
3		25.8	84.4	15.6	20.1 (27.9)		
4		24.5	85.2	14.8	20.1 (27.9)		
5		27.9	34.4	65.6	19.2 (26.7)		
6		27.9	30.0	70.0	19.2 (26.7)		
7		26.0	27.1	72.9	19.2 (26.7)		
8		27.5	71.0	29.0	19.7 (27.4)		
9		27.5	71.2	28.8	19.7 (27.4)		
10		27.5	70.4	29.6	19.7 (27.4)		
11	37.5	26.5	38.4	61.6	11.5 (16.0)		
12		26.0	36.4	63.6	11.5 (16.0)	48	£7.7
13		23.1	27.6	72.4	11.5 (16.0)		
14		26.5	34.4	65.6	18.6 (25.9)		
15		26.5	30.0	70.0	18.6 (25.9)		
16		26.5	27.1	72.9	18.6 (25.9)		
17		26.5	38.4	61.6	11.5 (16.0)		
18		26.0	36.4	63.6	11.5 (16.0)		
19		23.1	27.6	72.4	11.5 (16.0)		
21		22.5	84.6	15.4	20.1 (27.9)		
22		23.2	22.3	77.7	19.2 (26.7)		
23		22.5	68.9	31.1	19.7 (27.4)		
24		19.9	21.7	78.3	11.5 (16.0)		
25		23.2	22.3	77.7	18.6 (25.9)		
26		19.9	21.7	78.3	11.5 (16.0)		
Level 3							
7		14.1	81.3	18.7	20.1 (27.9)		
8		8.7	71.2	28.8	20.1 (27.9)		
9		21.7	20.9	79.1	19.2 (26.7)		
10		10.9	13.3	86.7	19.2 (26.7)		
11		17.7	53.7	46.3	19.7 (27.4)		
12		10.4	24.4	75.6	19.7 (27.4)		
13		19.2	20.1	79.9	11.5 (16.0)		
14		11.2	12.3	87.7	11.5 (16.0)	50	£7.4
15	37.5	21.7	20.9	79.1	18.6 (25.9)		
16		10.9	13.3	86.7	18.6 (25.9)		
17		19.2	20.1	79.9	11.5 (16.0)		
18		11.2	12.3	87.7	11.5 (16.0)		
19		8.7	50.2	49.8	20.1 (27.9)		
20		9.6	11.0	89.0	19.2 (26.7)		
21		9.1	12.6	87.4	19.7 (27.4)		
22		10.1	8.4	91.6	11.5 (16.0)		
23		9.6	11.0	89.6	18.6 (25.9)		
24		10.1	8.4	91.6	11.5 (16.0)		

(1) The correspondence between unit number and type of school and class is given in Figure 1.

TABLE 4

PUPIL STOCK PROJECTIONS FOR PRIMARY SCHOOL (IN THOUSANDS)

YEAR	STOCK OF PUPILS
67/68	4862
68/69	5040
69/70	5183
70/71	5302
71/72	5381
72/73	5432
73/74	5466
74/75	5491
75/76	5517

PROJECTIONS FOR STUDENT STOCKS IN SECONDARY SCHOOL ACCORDING TO THE DIFFERENT ALTERNATIVES (FIGURES IN THOUSANDS)(1)

YEAR	ALTERNATIVES											
	1'	1	2A	2B	2C	3A	3B	3C	4A	4B	4C	4A*
67/68	3174	3174 (1.9)	3174 (1.9)	3174 (1.9)	3174 (1.9)	3174 (1.9)	3174 (1.9)	3174 (1.9)	3174 (1.9)	3174 (1.9)	3174 (1.9)	3174
68/69	3208	3235 (2.6)	3235 (2.6)	3235 (2.6)	3235 (2.6)	3235 (2.6)	3235 (2.6)	3235 (2.6)	3235 (2.6)	3235 (2.6)	3235 (2.6)	3235
69/70	3258	3318 (3.1)	3318 (10.7)	3318 (6.6)	3318 (5.2)	3318 (3.1)	3318 (3.1)	3318 (3.1)	3318 (3.1)	3318 (3.1)	3318 (3.1)	3318
70/71	3323	3421 (3.7)	3674 (4.2)	3537	3492	3421 (10.6)	3421 (6.9)	3421 (5.5)	3421 (3.7)	3421 (3.7)	3421 (3.7)	3421
71/72	3412	3549	3828	3803	3703	3784	3657	3611	3549 (10.3)	3549 (6.8)	3549 (5.7)	3549
72/73	3508	3692	3982	3969	3947	3961	3936	3836	3916	3792	3751	3916
73/74	3624	3856	4135	4134	4124	4134	4122	4097	4113	4086	3991	4066
74/75	3751	4034	4297	4297	4296	4297	4296	4286	4296	4283	4259	4213
75/76	3873	4214	4460	4460	4460	4460	4460	4459	4460	4459	4449	4375

(1) Numbers in brackets express the percentage increase from one year to the next.

TABLE 6

THE DEVELOPMENT OF TEACHER STOCKS IN THE SYSTEM AS A WHOLE UNDER THE MAIN ALTERNATIVES 2A, 3A, 4A [1]

(IN HUNDREDS)

YEAR	ALTERNATIVES								
	2A			3A			4A		
	Non grad	Grad	Total	Non grad	Grad	Total	Non grad	Grad	Total
66/67	2645	952	3597	2445	952	3597	2645	952	3597
	(2.1)	(0.3)		(2.1)	(0.3)		(2.1)	(0.3)	
67/68	2701	955	3656	2701	955	3656	2701	955	3656
	(3.5)	(1.3)		(3.5)	(1.5)		(3.5)	(1.3)	
68/69	2795	967	3746	2795	967	3746	2795	967	3746
	(2.3)	(2.1)		(2.3)	(2.1)		(2.3)	(2.1)	
69/70	2860	987	3847	2860	987	3847	2860	987	3847
	(8.0)	(7.2)		(2.8)	(3.0)		(2.8)	(3.0)	
70/71	3090	1058	4148	2939	1017	3956	2939	1017	3956
	(3.1)	(5.2)		(7.3)	(7.5)		(2.6)	(3.6)	
71/72	3185	1113	4298	3153	1093	4246	3014	1054	4068
	(2.4)	(5.4)		(3.2)	(5.7)		(6.7)	(8.0)	
72/73	3261	1173	4434	3253	1155	4408	3217	1138	4355
	(2.1)	(4.8)		(2.3)	(5.4)		(3.2)	(6.2)	
73/74	3328	1229	4557	3328	1217	4545	3320	1209	4529
	(2.0)	(4.5)		(2.0)	(5.5)		(2.3)	(6.1)	
74/75	3396	1284	4680	3396	1284	4680	3396	1283	4679
	(2.3)	(4.0)		(2.3)	(4.0)		(2.3)	(4.1)	
75/76	3473	1335	4808	3473	1335	4808	3473	1335	4808

(1) Number in brackets gives the percentage average change from one year to the next.

TABLE 7

DEVELOPMENT OF TEACHER STOCKS IN PRIMARY AND FOUR FIRST YEARS OF SECONDARY SCHOOL (IN HUNDREDS) (1)

	Primary school (level 1)			Secondary school (level 2)				
Year	Non grad	Grad	Total	Non grad	Grad	Total	Total non grad	Total grad
66/67	1536	79	1615	958	492	1450	2494	571
67/68	1589	81	1670	964	498	1462	2553	579
68/69	1643	83	1726	986	503	1473	2629	586
69/70	1691	83	1774	986	512	1498	2677	595
70/71	1730	85	1815	1009	526	1535	2739	611
71/72	1754	89	1843	1038	544	1582	2792	633
72/73	1766	93	1859	1068	558	1626	2834	651
73/74	1773	98	1871	1103	575	1678	2876	673
74/75	1780	99	1879	1142	598	1740	2922	697
75/76	1789	99	1888	1182	617	1799	2971	716

(1) Teacher requirements in this part of the system are not influenced by the decision in question.

TABLE 8

DEVELOPMENT OF TEACHER STOCKS IN THE THREE LAST YEARS OF SECONDARY SCHOOL
(in hundreds)

YEAR	ALTERNATIVES																	
	2A		2B		2C		3A		3B		3C		4A		4B		4C	
	Non-grad.	Grad.	Non-grad.	Grad.	Non-grad.	Grad.	Non-grad.	Grad.	Non-grad.	Grad.	Non-grad.	Grad.	Non-grad.	Grad.	Non-grad.	Grad.	Non-grad.	Grad.
66/67	151	381	151	381	151	381	151	381	151	381	151	381	151	381	151	381	151	381
67/68	148	376	148	376	148	376	148	376	148	376	148	376	148	376	148	376	148	376
68/69	166	381	166	381	166	381	166	381	166	381	166	381	166	381	166	381	166	381
69/70	183	392	183	392	183	392	183	392	183	392	183	392	183	392	183	392	183	392
70/71	351	447	269	425	242	417	200	406	200	406	200	406	200	406	200	406	200	406
71/72	393	480	376	468	317	448	361	460	287	437	259	431	222	421	222	421	222	421
72/73	427	522	422	512	407	500	419	504	398	496	338	476	383	487	309	467	284	463
73/74	452	556	452	554	450	545	452	554	448	543	432	529	444	536	423	525	364	507
74/75	474	587	474	587	474	586	474	587	474	586	470	577	474	586	469	574	451	564
75/76	502	619	502	619	502	619	502	619	502	619	502	619	502	619	502	619	498	610

Table 9

REQUIRED INVESTMENTS BY LEVEL AND FOR THE WHOLE SYSTEM
(in mill. pounds)

Year	Primary	4 first years of secondary	Alternatives																	
			2A		2B		2C		3A		3B		3C		4A		4B		4C	
			3 last years of secondary	Total		Total		Total		Total		Total		Total		Total		Total		Total
67/68	33.5	10.6	0	44.1	0	44.1	0	44.1	0	44.1	0	44.1	0	44.1	0	44.1	0	44.1	0	44.1
68/69	32.8	10.9	9.0	52.7	9.0	52.7	9.0	52.7	9.0	52.7	9.0	52.7	9.0	52.7	9.0	52.7	9.0	52.7	9.0	52.7
69/70	29.4	19.5	11.5	60.4	11.5	60.4	11.5	60.4	11.5	60.4	11.5	60.4	11.5	60.4	11.5	60.4	11.5	60.4	11.5	60.4
70/71	24.3	24.5	107.1	155.9	56.4	105.2	39.5	88.4	13.5	62.4	13.5	62.4	13.5	62.4	13.5	62.4	13.5	62.4	13.5	62.4
71/72	16.4	30.9	25.8	73.1	67.5	114.8	47.3	94.6	103.4	150.7	56.1	103.4	39.3	86.6	16.3	63.6	16.3	63.6	16.3	63.6
72/73	10.5	28.8	28.1	67.4	32.5	71.8	61.3	100.6	36.3	75.7	74.4	113.7	54.2	93.5	106.9	146.2	61.1	100.4	45.7	85.1
73/74	6.9	35.7	21.1	63.7	25.4	68.0	30.1	72.7	28.4	71.0	33.0	75.6	61.1	103.6	37.0	79.6	73.0	115.6	53.0	95.6
74/75	5.2	41.4	18.3	64.8	18.6	65.2	22.0	68.5	18.8	65.3	23.1	69.6	28.3	74.8	26.3	72.8	31.2	77.7	57.8	104.3
75/76	5.2	38.1	22.1	65.4	22.2	65.5	22.4	65.7	22.2	65.5	22.4	65.8	26.1	69.5	22.5	65.8	27.2	70.5	32.1	75.5
Total				647.7		647.7		647.7		647.7		647.7		647.5		647.7		647.4		643.7