IMPORTANT NOTICE

THE EFFICIENT ALLOCATION OF RESOURCES IN EDUCATION:
A Planning Model With Applications to Northern Nigeria

A thesis presented

by

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to

The Department of Economics

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

in the subject of

Economics

Harvard University

Cambridge, Massachusetts

September, 1965

THESIS SUMMARY

Title: Efficient Allocation of Resources in Education: A Planning Model with Application to Northern Nigeria

This thesis is addressed to the major problems of planning resource allocation for the educational sector, namely:

(a) the determination of the total amount of resource use;

(b) the distribution of the total among the various educational institutions or groups of institutions;

(c) the choice of the productive techniques in each producing unit and

(d) the choice of importation or exportation of educated labor.

A dynamic linear programming model of the educational system is developed in the first 5 chapters of the thesis and applied to the above questions using data from Northern Nigeria in the remaining chapters. The model used in the thesis differs from most existing approaches to educational planning in the following ways:

(a) It is based on the principle of constrained maximization and involves the explicit consideration of both the cost and the benefits of various educational expenditures.

(b) Use of the model allows the simultaneous computation of optimal levels of output of each type of education,

the optimal pattern of importation and exportation of educated labor, and the choice of efficient educational technologies.

(c) The model is intended to be applied in an economy in which each category of educated labor is highly substitutable both vis-a-vis other labor inputs and vis-a-vis capital, and in this respect it differs from most other planning approaches, which assume that the production functions in the economy are characterised by fixed input coefficients for labor classified by occupational group or educational level.

(d) It deals directly with labor classified by educational attainments. This feature of the model avoids the difficult problem of translating demands for labor classified by occupational group and the demand for the outputs of specific educational institutions.

Chapter 1 is an introduction to the thesis containing a discussion of present educational planning methods. Chapter 2 is devoted to a discussion of the benefits and costs of education and the concept of economic efficiency in education. The formal structure of the model used in this thesis is presented in Chapter 3. An appendix to Chapter 3 suggests a method of testing the optimality of factor substitution in productions within the framework of a linear model.

Chapter 4 is a brief introduction to the economics of the Northern Nigerian educational system and a discussion of some of the problems involved in the implementation of the model.

Chapter 5 contains estimates of the production functions for each type of education. Particular attention is paid to the course of technological change in the production of education and the resulting temporal movement in the input coefficients in the model.

Chapter 6 contains a discussion of the demand for educated labor in the Northern Nigerian economy. On the basis of earnings data collected in a sample survey of private establishments, the coefficients of the objective function, representing the present value of net benefits associated with each type of education, are estimated.

Chapter 7 presents the main results of the model. In addition to a number of runs using parameters reflecting the existing structure of the educational system and the existing productive techniques, a large number of solutions have been computed to test the following types of variation:

(a) alterations in the productive processes, such as a change in the primary school course from seven years to five years;

(b) structural change in the system; for example, altering the method by which university students are prepared for higher education;

(c) analysis of the economic implications of changes in the efficienty of a given process;

(d) analysis of some economic aspects of the trade-off between quality and quantity in education with particular reference to the primary school level;

(e) analysis of the possibilities of substitution between inputs in the production of primary education, namely the substitution of audio-visual and other equipment for poorly trained teachers, and the substitution of better trained teachers for poorly trained teachers.

An appendix to chapter 7 analyses the sensitivity of the model to error in construction and an estimation. A second appendix presents a comparison of the results generated by this model with a recent Northern Nigerian educational plan.

Chapter 8 suggests a number of extensions to the model and contains a brief critical evaluation of the approach suggested here.

Samuel Bowles

September 1965

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A GLOSSARY OF NOTATION

Notation relating to the instrument variables:

X_j^p = the number of students admitted to level j in period p; j=1...m, p=1...n.

m = the number of activities.

n = the number of years in the planning period.

$\bar{X}_j^t$ = the total enrollments in activity j in period t.

$\bar{X}_{fj}^p$ = the imports of foreign teachers of type j in period p.

x = a column vector (nm x 1) of activity levels.

Notation relating primarily to the constraint equations:

a_{ij}^t = the minimum input of resource i in period t required to accommodate one student at activity j; t=1...n, j=1...m, i=1...m+q.

q = number of exogenously supplied inputs.

A = the matrix (nm x nm) of input coefficients (a_{ij}^t's) for endogenously supplied inputs; i=1...m, j=1...m, t=1...n.

$\bar{A}$ = the matrix (qm x nm) of input coefficients (a_{ij}^t's) for exogenously supplied inputs; i=m+1...q, j=1...m, t=1...n.

B_j^t = the quantum of resource j available to the system in time t.

b = the column vector (nm x 1) of resource availabilities, B_j^t for j=1...m.

$\bar{b}$ = the column vector (qn x 1) of the availabilities of exogenously supplied inputs; B_j^t for j=m+1,..q.

$\bar{B}_j^t$ = total of resource j available to the system in time t, including endogenously generated outputs of j.

b_i^t = the estimated stock of teachers of type i surviving until time t from the base year.

h = a column vector (nm x 1) of lower bounds on the activity levels; h^p_j; for j=1...m, p=1...n.

r = a column vector (nm x 1) of upper bounds on the activity levels r^p_j, for j=1...m, p=1...n.

s_j = the length of course j in years.

d_j = the expected annual rate of retirement from the teaching force for teachers of type j.

X^t_{ij} = the amount of input i devoted to activity j in period t.

T_{ij} = demand for teachers of qualification i in activity j.

Notation relating primarily to the objective function:

Z^p_j = the net benefits function coefficient associated with activity X^p_j.

z = the row vector (1 x nm) of net benefits coefficients, Z^p_j.

Y^p_j = the present value (discounted to year 1) of the earnings accruing to an output of activity X^p_j.

$Y^p_{j'}$ = the present value (discounted to year 1) of the alternative earnings stream, namely that which would have accrued to the individual had he not received education at activity j.

C^p_j = the present value (discounted to year 1) of the per student cost of operating sctivity X^p_j for the entire course of s_j years.

i = the rate of social time discount.

y^p_{jt} = expected earnings of the output of activity X^p_j in time t; $y^p_{jt} = 0$ for $t < p + s_j$.

y'_{jt} = expected earnings in time t of an individual possessing the prerequisites for entry into x^p_j but who enters the labor force at time p.

c^p_{jt} = per student cost of operation of X^p_j in time t; $c^p_{jt} = 0$ for $t \geq p + s_j$, $C^p_{jt} = 0$ for $t < p$.

c_{it} = the social marginal cost or the opportunity cost of one unit of input i in time t.

l_j = expected length of working life after graduation from activity j.

$l_{j'}$ = expected length of working life after obtaining the prerequisites for entry into activity j.

g_j = the fraction of the total admissions to activity X_j which is expected to complete successfully the course.

Other notation:

L_i = gross production of labor educated to level i.

L_{ij} = the amount of labor of type i allocated to sector j.

Chapter 1. INTRODUCTION

The educational systems in most societies are expected to perform a multiplicity of functions. In broad outline we can distinguish the selection function, namely the job of channeling youth in the direction of appropriate occupational and other adult roles, and the socialization function, namely the preparation of youth for the performance of their adult roles. A major element of the socialization function is the transformation of labor characterized by one set of skills and mode of economic behavior to labor characterized by different skills and behavior.

To the economist, the educational system is an aggregation of production processes, each of which uses a variety of inputs (both human and physical) to transform raw materials (the uneducated) or intermediate goods (continuing students) into an output for which there is a demand.[1] The efficiency of this system as a producer of educated labor is the subject of this essay.

1.2. The Necessity and Scope of Educational Planning.

Most communities have recognized the need for government intervention in the educational system: From the economic standpoint the long period of production and the very great durability of the output alone provide adequate justification for the exercise of some degree

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1. The system concurrently produces a consumers good, "education". See below, section 2.2.

of conscious social control over the allocation of resources in the educational system.

The major economic problems of planning resource allocation for the educational sector are:

a. the determination of the total amount of resource use;

b. the distribution of the total among the different educational institutions or groups of institutions;

c. the choice of the productive techniques in each producing unit; and

d. the choice of importation versus domestic production of educated labor.

Solution to these four major problems determines the pattern of student enrollments and the use of teachers and other resources throughout the system.[2]

1.3. Present Educational Planning Methods.

There is little agreement among planners and economists as to the best educational planning methods.[3]

In terms of actual application, however, one general group of methods is by far the most important: this is the manpower require-

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2. In a more comprehensive treatment, the problems of the efficient utilization as well as the efficient production of educated labor should be considered.

3. A general review of a number of planning methods can be found in William G. Bowen, "Assessing the Economic Contribution of Education: An Appraisal of Alternative Approaches," in Economic Aspects of Education (Princeton: Princeton University Press, 1964); and Russell G. Davis, Planning for Human Resource Development: Models and Schemata. (forthcoming).

ments approach.[4] Because of its widespread use, its distinguished proponents, and the significant differences between it and the method proposed in the chapters below, it is useful to consider an outline of this method and some of the major criticisms made against it.[5]

Although there is considerable variety within what may be termed the "manpower requirements school," all of the major versions rely on estimates of the type briefly outlined below:

a. an estimate of national income at some target date (or at a number of dates), usually disaggregated by sector. This estimate along with estimated labor input coefficients allows:

b. an estimate of the target year total labor force classified by occupational group and generally by sector. The estimated distribution of educational attainments for each occupational group and estimate (b) is the basis for:

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4. While adherents of the approach relying on computations which relate future streams of benefits and costs of particular types of education have made significant contributions to both the theoretical and empirical literature on the economics of education, I am aware of only one attempt to employ the approach in a direct policy advisory capacity, namely: Carl S. Shoup, et.al., The Fiscal System of Venezuela, a Report of the Commission to Study the Fiscal System of Venezuela (Baltimore: The Johns Hopkins Press, 1959), pp. 406-409.

5. Three major variations on the manpower requirements theme are Jan Tinbergen and H.C. Bos, Econometric Models of Education (Paris: OECD, 1965), which presents a revised version of the model proposed by J. Tinbergen and H. Correa, "Quantative Adaption of Education to Accelerated Growth, Kyklos, Vol. XV (1962), Fasc. 4, pp. 776-786; Herbert Parnes, Forecasting Educational Needs for Economic and Social Development (Paris: OECD, 1962), which presents the methodology underlying the OECD's Mediterranean Regional Project on educational planning; and Richard S. Eckaus, "Economic Criteria for Education and Training," Review of Economics and Statistics, Vol. XLVI, No. 2 (May, 1964), pp. 181-90.

c. an estimate of the number or workers with each type of educational qualification in the terminal year labor force.[6]

In order to relate the information contained in estimate (c) to the resulting necessary educational enrollments and outputs, a further estimate is made, namely:

d. the existing (base year) stock of each type of labor classified by educational level and the expected rate of retirement, immigration, and emigration for each type of labor.

The manpower requirements approach has been widely accepted and at the same time, subjected to considerable criticism. The following shortcomings of the method are probably the most important.[7]

First, there are serious methodological problems concerning the concept of a manpower "requirement" or a "shortage" of any given type of labor. To specify that a given number of personnel of type $x(L_x)$ are "required" in year t implies that the elasticity of substitution between L_x and all other inputs is zero, and that in addition, the elasticity of demand for the outputs produced by L_x is also zero. If either of these two assumptions does not hold, the demand curve for L_x will have an elasticity greater (in absolute value) than zero, and in this case, the amount of labor demanded will depend, among other

6. Tinbergen's model (referring to both the original with Correa and the revised edition with Bos) estimates the educational composition of the labor force directly from the national income figures without reference to the occupational structure of the labor force.

7. The main contributors to the manpower requirements approach are well aware of these shortcomings; in fact, a number of penetrating criticisms of the approach have been written by economists who have contributed significantly in its development.

things, on its own price and that of near substitutes (if any) and the price of the output to which it contributes, and the price of sutstitutes for the output (if any).[8] Where it can be argued that the input of labor (L_x) depends not only on the level of output, but also on the price of L_x (and hence, on the supply of L_x available),[9] the manpower requirements approach becomes untenable, as the "requirements" for each type of labor are in this case not independent of the supply.[10]

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8. A number of writers have commented on the difficulty in giving the terms "shortage" or "requirement" any operational meaning in terms of numbers of workers where the economy is not charactersed by production functions with fixed labor input coefficients. Cf. especially, OECD, Directorate for Scientific Affairs, "Technical Evaluation of the First Stage of the Meditarranean Regional Project" (Paris: May, 1965), pp. 31-36, (Mimeographed.), and Harvey Leibenstein, "Shortages and Surpluses in Education in Underdeveloped Countries: A Theoretical Foray," a Paper presented to the conference on Education and Economic Development, Chicago, April 4-6, 1963 (Mimeographed.) In addition, P.J. Verdoom in "Complementarity and Long Range Projections," Econometrica, Vol. 25, no. 4 (October, 1956), pp. 451-66, discusses the relationship between the use of fixed input coefficients production functions and the appearance of discrepancies between the supply and demand for labor and other factors. See especially p. 432. G. Stigler and D. Blank [The Demand and Supply of Scientific Personnel (New York: National Bureau of Economic Research, 1957), pp. 23-24], and K. Arrow and W.M. Capron [Dynamic Shortage and Price Rises: the Engineer-Scientist Case," Quarterly Journal of Economics, Vol. LXXIII, No. 2 (May, 1959), pp. 292-308], have developed definitions of a manpower shortage which presuppose an elastic demand curve for labor, but both definitions rely on the movement of wages, a variable conspicuously absent from the work of the manpower requirements school.

9. Assuming that the supply of L_x has some impact on its price, i.e. that wage controls and other rigidities are unimportant.

10. "It is not surprising that users of the manpower requirements approach have generally overlooked these supply effects, since the rationale of the approach is dominated by the view that an economic plan or forecast is already given, and that this generates a unique set of demands for various types of labor which the educational system must be adjusted to supply..." OECD, Directorate for Scientific Affairs, "Technical Evaluation..., p.32.

A number of recent pieces of research have cast the fixed labor input coefficients assumptions required by the manpower requirements approach into question. First, work by Arrow, Chenery, Minhas, and Solow and Minasian suggests an elasticity of substitution between capital and labor which is significantly different from zero in virtually all of the industries studied. The median observations were much closer to -1, although in many cases were significantly different from that figure.[11] Second, studies based on engineering data provide evidence of a considerable range of substitutability between categories of labor classified by level of educational attainment. Third, Houthakker has demonstrated that even where each individual firm operates with a fixed input coefficients production function, the aggregate production function will have a non-zero elasticity of substitution if a number of assumptions are fulfilled.[13]

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11. K.J. Arrow, H.B. Chenery, B.S. Minhas, and R.M. Solow, "Capital-Labor Substitution and Economic Efficiency," Review of Economics and Statistics, Vol. XLIII, No. 3 (August, 1961), pp. 225-250. B.S. Minhas, An International Comparison of Factor Costs and Factor Use (Amsterdam: North-Holland Publishing Company, 1963), pp. 17-26; and Jora B. Minasian, "Elasticities of Substitution and Constant Output Demand Curves for Labor," Journal of Political Economy, Vol. LXIX, No. 3 (June, 1961), pp. 261-270. Lief Johansen has suggested the possibility that even where the existing capital stock requires a fixed input of labor, there are substitution possibilities with respect to increments in the capital stock, "Substitution vs. Fixed Coefficients in the Theory of Economic Growth: A Synthesis," Econometrica, Vol. 27 (April, 1959), p. 158.

12. Cf. G.K. Boon, Economic Choice of Human and Physical Factors in Production: An Attempt to Measure the Micro-economic and Macro-economic Possibilities of Variation in Factor Proportion of Productions (Amsterdam: North-Holland Publishing Company, 1964), especially pp. 105-172, 222, 253, and 319.

13. H. Houthakker, "The Pareto Distribution and the Cobb-Douglas Production Function in Activity Analysis," Review of Economic Studies, Vol. XXIII, no. 1 (1955-56), pp. 27-31.

Fourth, international comparisons of the labor inputs classified by occupational group and by sector indicate that substantial substitution possibilities exist.[14] Fifth, there is some historical evidence that even with a given set of plant and machinery considerable factor substitution is possible.[15]

The above outline of evidence contrary to the fixed labor input coefficients assumption would be of limited interest were it not for the fact that the results of the manpower requirements approach are apparently quite sensitive to a plausible degree of factor substitution in production.[16]

A second major criticism of the manpower requirements approach is that, even if one knew the precise occupational composition of the

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14. Herbert Parnes, Forecasting Educational Needs..., pp. 90-97; OECD, Directorate for Scientific Affairs, "Technical Evaluation...", p. 52 and Table V. The last cited item presents an international comparison of labor input coefficients classified by occupation and sector, and suggests that a high degree of substitutability exists "for almost any given occupation in any given sector." Moreover, even using educational rather than occupational categories, A.K. Sen concluded on the basis of a 9-country comparison that there is "flexibility of educational requirements arising from the fact that there is considerable substitutability between men with different periods of formal education and also between educated men and other factors of production such as machinery." A.K.Sen, "Comment" on J. Tinbergen and H.C. Bos, "A Planning Model for the Educational Requirements of Economic Development", The Residual Factor and Economic Growth (OECD: Paris, 1964), p.193.

15. See Gustav Ranis, "Factor Proportions in Japanese Economic Development," American Economic Review, Vol. 47, No. 4 (September 1957), pp. 594-607.

16. A sensitivity analysis of the results of the Mediterranean Regional Project of the OECD reports that "realistic substitution possibilities can make important differences in the final educational estimates, that the educational estimates are, in fact, sensitive to possible supply effects on the conditions of demand for workers in various occupations." OECD, Directorate for Scientific Affairs, "Technical Evaluation...", p.61.

labor force at the target date, this would not yield a determinate pattern of educational enrollments because of the fact that there is no unique educational background required for the performance of each occupation.[17] Whereas, in any given institutional setting, the educational prerequisites for some jobs (e.g. lawyer, doctor) are quite specific, in general there are a variety of combinations of education, training, and experience which will produce the skills required for the performance of any given job. The large dispersion of educational attainments around the mean for each occupational group is clearly demonstrated in the U.S. Census data on education and employment.[18] The level of educational attainment associated with the performance of a given occupation is, in general, not technologically given but the result of an economic choice. This fact further contributes to the interdependence between the supply and demand

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17. "As a rule, one occupation can be taken by people with different educational backgrounds," J.Tinbergen, "Educational Assessments," in UNESCO, Economic and Social Aspects of Educational Planning (Paris: UNESCO, 1964), p.189; see also, OECD, Directorate for Scientific Affairs, "Technical Evaluation...," pp. 38-39; and Frederick Harbison and C. Myers, Education, Manpower, and Economic Growth (New York: McGraw-Hill Book Co., 1964), p.186; and R.S. Eckhaus, "A Research Program on the Economic Requirements for Education and Training--Italy" (Cambridge: M.I.T, 1962), p.7. (Mimeographed.)

18. Even using a highly disaggregated occupational classification (494 occupational groups) the Census Bureau found a wide dispersal for almost all occupations, even those with apparently specific educational prerequisites (e.g. the various categories of engineers). U.S. Department of Commerce, U.S. Census of Population, 1960, Final Report PC(2)-1713 Occupations by Earnings and Education. For similar data on Canada, India, Italy and England, Wales and Japan, Cf. Herbert Parnes, Forecasting Educational Needs...," pp. 106-111. For a general discussion of this problem, see Herbert Parnes, "Relation of Occupation to Educational Qualification," in OECD, Planning Education for Economic and Social Development (Paris: OECD, 1964), pp. 147-158.

for educated labor; educational requirements for a job depend in part on the supply of various types of educated labor.

Even if the shortcomings presented thus far were overcome, the manpower requirements method would still be subject to a third criticism. The method does not allow the evaluation of educational policy choices in terms of the relative social benefits and costs of each alternative. The educational targets derived from the method thus have no direct significance as far as the efficiency of resource allocation is concerned.[19] This problem arises because:

a. there is no endogenous consideration of the costs of producing the "required" manpower[20] and

b. no attempt is made to evaluate the benefits associated with an increase in the availability of each type of labor.

The fourth shortcoming of the manpower approach is that it relies on the use of data which are either not generally available to

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19. A.K. Sen, commenting on Tinbergen's model has suggested that "it is in analysing minimum educational requirements, rather than in clarifying optimum educational planning", that the Tinbergen/Bos models have something substantial to offer." "Comment", p. 197. William Bowen, ("Assessing the Economic Contribution...") is critical of the manpower requirements school on the same general grounds: "...estimates of the future number of people with a given kind of training who are 'needed' or 'wanted' are rather devoid of meaningunless one also has a good idea of the relation between the benefits to be obtained by having this number of trained persons and the costs involved in having them."(p.36.)

20. However, Robinson Hollister has suggested a planning strategy which seeks to define a least cost configuration of education and training consistent with a projected future occupational pattern. (R.F.Hollister, "The Economies of Manpower Forecasting," International Labour Review, vol.LXXXIX, no.4, (April 1964), p. 385.

planners, or not likely to be particularly accurate. The reliance on the main economic aggregates (total labor force, national income, etc.) is a serious weakness if the method is intended for application in countries with underdeveloped statistical services. Estimates of the rate of change of labor productivity by occupational groups and industrial sector play a particularly important part in the method.[21] Yet the existing work on productivity increase indicates considerable diversity both between sectors and over time in the movement of labor productivity, and attempts to explain these variations statistically have proven somewhat disappointing.[22] The reliance on estimates of future productivity

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21. The movement from estimate (a) to estimate (b) on p.3 above requires the knowledge of future productivity trends.

22. See especially John Kendrick, Productivity Trends in the U.S. (Princeton: Princeton University Press, 1961), pp. 151-164 and p. 187. Using these figures for the output per unit of labor input grouped by industry, Kendrick found that the mean deviation of decade rates of increase in labor productivity from the secular rate of 1899-1953 was in some cases (farming) as large as the secular rate itself, and in most cases greater than one third of the secular rate. (p. 153). See also J. Kendrick, "National Productivity and its Long Term Projections," Conference on Research in Income and Wealth, Long Range Economic Projection (Princeton: National Bureau of Economic Research, 1954), p. 67-106. A study of Japanese economic growth has revealed a considerable degree of variability in labor productivity: "Because of the large differences in productivity, the pattern of employment does not change in the same way as the pattern of output." [H.B. Chenery, S. Shishido, and T. Watanabe, "The Pattern of Japanese Growth, 1914-54," Econometrica, Vol. 30, No. 1 (January 1962), p. 125.] The above studies deal with labor productivity defined for all types of labor. Hollister has pointed out the possibility that much of the variability in the productivity changes in terms of the aggregates labor input coefficients may arise from variability in the inputs of relatively unskilled labor or other categories of labor which are unimportant from the standpoint of educational planning. (R.G. Hollister, "The Economics of Manpower Forecasting," p. 378.)

and national income may be a serious shortcoming, as it has been shown that the results of at least one major application of the manpower requirements approach are highly sensitive to errors in these particular estimates.[23]

In order to be manageable a planning method must involve a considerable degree of abstraction, and while the assumptions underlying the manpower requirements method undoubtedly do violence to reality in numerous particular planning situations, planning methods outside the field of manpower and education have produced useful results on the basis of similar, and, in some cases, more extreme assumptions.[24] Thus, while the above paragraphs have pointed out a number of shortcomings of the manpower requirements approach, there is a wide range of planning situations in which the method can be fruitfully applied.

a. The manpower requirements approach is probably well suited to short run problems, for there is good reason to believe that the short run elasticity of demand for a given type of labor will be less than the long run elasticity.

b. Particular sectors and/or particular occupations may correspond more closely than the entire economy to the assumptions used in the manpower requirements approach. In these cases the manpower

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23. OECD, Directorate for Scientific Affairs, "Technical Evaluation...", p. 67.

24. The application of input-output analysis to problems of economic projection is a case in point.

requirements method is likely to yield useful results.[25]

c. Any attempt to measure the economic benefits of an educational process must rely on some estimate of the future demand for educated labor. The results of a manpower requirements analysis may give a rough indication of the likely position of the demand curves for labor at various future dates; in this sense the manpower requirements approach can be complementary to a more general method embodying a comparison of the benefits and costs of educational processes.

1.4 An Outline of Aims.

The purpose of this paper is: first, to present the major economic decisions concerning education in the framework of constrained maximization (Chapter 2). Second, I will develop (in Chapter 3) a planning approach which:

a. addresses itself to the concrete planning problems of enrollments, changes in educational technology, and aggregate resource use by the educational system;

b. facilitates the consistent treatment of the benefits and costs of the major policy alternatives;

c. allows for an economy characterized by a high degree of substitutability among different categories of labor and between labor and capital;

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25. The Indian Planning Commission has devoted considerable attention to studies of the requirements for labor with specific skills for which the elasticity of substitution with other types of labor was thought to be low (e.g. engineers and selected scientific personnel). See the research papers cited in: Government of India, Planning Commission, "Unofficial List of Major Manpower Publications" (New Delhi, Government of India, n.d.) (Mimeographed.)

d. is not particularly sensitive to a reasonable degree of error in the main parameters and, which utilizes information which is either available or inexpensive to generate.

Third, I will illustrate the above model by its operation using Northern Nigerian data. (Chapters 4-7.)

Chapter 2. ECONOMIC EFFICIENCY IN EDUCATION

This chapter is a discussion of some of the economic aspects of education and an outline of the conditions for the efficient allocation of resources in the educational system. This first section is an introduction and a clarification of a number of points. In section 2.2 the benefits and costs of education are considered. Section 2.3 is a discussion of the treatment of non-economic benefits and costs of the educational system. Section 2.4 presents a highly simplified model of the educational system and the economy. Conditions for the efficient allocation of resources are derived.

Before proceeding, the following clarifications should be made. In this essay, the output of the educational system will be defined in terms of number of students graduated. The value of the educational output will be defined below (section 2.2) as the net present value of the education received. There are two concepts of the demand for education. The first is derived from the production functions in the economy; this demand function is synonymous with the marginal productivity functions for each type of educational output and represents the demand by employers for the products of the educational system. The second can be called the demand for getting an education, and it is a function of the income and the preference function of the consumer, the price of education, and the expected future benefits, monetary and otherwise, attributable to getting the education in question. In this essay, the primary emphasis is on the

first type; the present value of the educational output as defined below depends directly on the future production functions in the economy and on the marginal productivity functions derived from them.

It is assumed in this chapter that the distribution of ability among those attending school is identical with those who did not. Thus, any difference in productivity between two types of labor classified by level of educational attainment is the result of differences in education. It is further assumed that the social time discount rate is given and that it is not a function of any of the educational or economic instrument variables when operated over the feasible range.

2.2. The Social Benefits and Costs of Education.[1]

a. The Benefits.

Any consequence of the educational system's output which results in an increase in total social utility is here defined as a benefit of education. As the utility function presumably contains many components it is useful to distinguish between those benefits which operate via the income or income-related terms of the utility

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1. The material presented here draws heavily on the works below, and on the works cited therein: T.W. Schultz, The Economic Value of Education (New York: Columbia Univ. Press, 1963); T.W.Schultz, "Education and Economic Growth,"; T.W. Schultz, "Capital Formation by Education," Journal of Political Economy, Vol.LXVIII, No. 6 (December 1962), pp. 571-83; Burton Weisbrod, "Education and Investment in Human Capital," Journal of Political Economy, Vol. 70, No.5,part 2 (October 1962),pp. 196-233; H.A. Houthakker, "Education and Income," Review of Economics and Statistics, Vol. 41, No.1(February 1959), pp.24-28; Gary Becker, Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education (New York: National Bureau of Economics Research, 1964); Herman Miller, "Income and Education: Does Education Pay Off?" in Selma Mushkin (ed.), Economics of Higher Education (Washington, U.S. Dept. of Health, Education, and Welfare, 1962), pp. 129-146.

function, and those which operate on other components. We will call the former "economic" and the latter "non-economic", although any dichotomous distinction of this type is bound to be somewhat arbitrary. This classification excludes from the category of "economic" benefits those consequences of education generally called "consumption benefits," namely, those which accrue to the student in the form of pleasure in studying or later in pleasure in being an educated man and having access to the style of life open to those with education.

Economic benefits as defined here are measured by the increase in an individual's social marginal productivity resulting from his education. The social marginal productivity of an educational output can be described as the total effect on future national income attributable to the output's education, taking into account his direct contribution to output, as well as any external effects which may exist.[2] External effects of one man's education include:

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2. Although the articles cited in note 1 (above) contain ample evidence of a positive association between years of schooling and productivity, there is not a simple relatioship between education and productivity, or even between education and the acquisition of occupational skills. A large number of psychological and physiological characteristics have an important bearing on productivity. (Cf. Hector Correa, The Economics of Human Resources (Amsterdam; North-Holland Publishing Company, 1962) pp. 22-50). It should also be stressed that the question of increased productivity is not a simple dichotomous one of being able or unable to perform certain jobs. Considerable variation is possible in the competence with which most jobs are performed so that education may contribute to economic growth both by making existing jobs more productive and by facilitating a change in the occupational structure of the labor force towards more productive jobs.

a. the effect of his education on other's productivity either through his efforts as a co-worker or manager, or through a variety of entrepreneurial activities;

b. the effect of his education on social costs such as welfare payments or police protection costs;

c. the external effects which are conferred on the parents or future progeny of the student (e.g. the custodial services of a school system).[3]

Other types of possible economic benefits are:

a. the reduction in the variance of income received through greater ability to absorb new skills and to thus avoid skill obsolescence;[4]

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3. Cf. Burton Weisbrod, The External Benefits of Public Education, an Economic Analysis (Princeton: Princeton University, Industrial Relations Section, 1964).

4. Jacob Mincer has presented United States data which indicate a positive relationship between years of schooling and likelihood of gaining admission to on-the-job training programs. (Jacob Minder, "On the Job Training: Costs, Returns, and Some Implications," Journal of Political Economy, Volume LXX, Number 5, Part 2 (October 1962), pp. 50-79, especially page 59.) The variability of income recieved may be increased if the educational system concentrates on specific vocational training rather than general education.

b. the increased mobility and hence increased likelihood or remunerative employment which is associated with the acquisition of education and the means for acquiring more perfect labor market information;[5]

c. the economic effects of the research which is produced as a joint product (along with the production of educated men) in some educational institutions;

d. the improvement in the total productivity of the labor force associated with the functioning of the educational system as an occupational selection process.

In the application of the concepts discussed here (see Chapter 6), the only aspect of benefits which has been estimated is the increase in private marginal productivity.

There is no necessity that all of the consequences of the educational output will affect an increase in social utility: "Negative benefits" of both the economic and non-economic type may occur. A "negative benefit" of education may be defined as an aspect of the output of the educational system which results in a reduction of total social utility through its effect on income. A category of

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5. Items a and b are phrased in terms of private benefits; their relevance to social benefits is that both greater trainability and greater mobility and labor market information probably contribute to the allocative efficiency of the economy. Cf. George Stigler, "Information in the Labor Market," Journal of Political Economy, Vol. LXX, No. 5, Pt. 2 (October 1962), pp. 94-105. Larry A. Sjaastad, "The Costs and Returns of Human Migration," Journal of Political Economy, Vol. LXX, No. 5 Pt. 2 (October 1962), pp. 80-93.

negative benefits, which is of considerable policy importance in many countries, is the effect which the acquisition of education may have on attitudes towards performing particular types of jobs or working in particular geographical areas. The resulting rigidities in the labor market often contribute to the problem of unemployment of educated labor and restrict the allocative efficiency of the economy. In particular, education may lead to inefficiency with respect to the spatial allocation of labor (e.g. rural-urban), and the occupational distribution of labor (e.g. white collar - blue collar; civil service - private employer). Another economically important type of negative benefits may arise if the spread of education is politically disruptive and the response of the government is an increase in military, police and other unproductive expenditures.[6]

B. The Costs.[7]

The cost of one student year is the sum of the inputs valued at their opportunity cost, that is, their social marginal productivity,

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6. These and other negative benefits have received little attention in the literature on education and economic growth. See, however, Gordon C. Ruscoe, Dysfunctionality in Jamaican Education (Ann Arbor: University of Michigan, School of Education, 1963), and John Vaizey, "Some of the Main Issues in the Strategy of Educational Supply" in OECD, Policy Conference on Economic Growth and Investment in Education, Washington October 16-20, 1961 (Paris: OECD, 1962), p.52.

7. In addition to the items cited in note 1 above, the following have been useful in clarifying the concepts of costs used here and in chapter 5: The Appendix, "The Costs of Education," pp. 122-125 in the Weisbrod article cited in note one above; and Rudolph C. Blitz, "The Nation's Educational Outlay" in Selma Mushkin, (ed.), The Economics of Higher Education (Washington; United States Department of Health, Education and Welfare, 1962), pp. 147-156.

in their next best use, or at their social marginal cost. The cost of education to the educational institution is not the relevant cost figure, as it includes items of private as well as social cost, such as feeding the students and perhaps housing and clothing them, services which if not undertaken at the school would have to be undertaken in the home.[8] The major components of direct costs considered in this study are the use of teachers' services, services of administrative and clerical personnel, educational materials, depreciation of the physical plant, and an interest charge on the cost of the physical plant. The indirect cost element relates to the withdrawal of students from the labor force (or their retention in the educational system) for the continuation of their education. Students' time should be valued at its opportunity cost, namely the social marginal productivity of the student if he were on the labor market. Measurement of the social marginal productivity of the student were he TO seek employment, must include consideration of his prospects for being employed, and the effects of his entry to the labor force on employment and productivity elsewhere.[9]

8. Naturally, if the marginal cost of these services when provided by the school differs from their marginal cost when provided at home, the difference (positive or negative) should be attributed to education.

9. It is sometimes suggested that the relevant measure is the social marginal productivity if the students of all of them were to enter the labor market. Weisbrod pointed out that this implies the consideration of drastic policy alternatives. "...studies involving the costs and benefits of education are surely not directed to the question of whether there should or should not be education. The issue is whether fewer or more people should be encouraged to go further in school. Only marginal changes are being contemplated." (Education and Investment...", Appendix, p.122). He suggests that the problem of unemployment of non-students should not be considered at all in estimating the opportunity costs of students' time, as the problem of allocative efficiency in education should not be confounded with the problem of achieving full employment. This approach appears to be unfounded. It is no more legitimate to assume full employment than toassume any other level in calculating the opportunity costs. From the planning standpoint it makes sense to assume a range of likely rates of unemployment, rather than the most desirable rate.

c. Net Benefits

The gross economic benefits of education per student at level j are defined as:

$$2.2.1 \qquad Y_j - Y_{j'} = \sum_{t=1}^{l_j+s_j} y_{jt}(1+i)^{-t+1} - \sum_{t=1}^{l_j+s_j} y_{j't}(1+i)^{-t+1}$$

where:

y_{jt} = the social marginal productivity of output j in time t;

$y_{j't}$ = the social marginal productivity in time t of an individual who enters the labor force with the prerequisites for entry to level j;[10]

i = the rate of social time discount;

l_j = the expected working life in years from the date of graduation from activity j;

s_j = the length of course j in years.

The present value of the costs per student at level j, C_j, are:

$$2.2.2 \qquad C_j = \sum_{t=1}^{s_j} \frac{\sum_{i=1}^{v} a_{ijt} C_{it}}{(1+i)^{t-1}}$$

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10. It should be noted that for $t \leq s_j$, $y_{jt} = 0$ and $y_{j't} > 0$. Thus the opportunity cost of withdrawing students from the labor stream is incorporated here as a subtraction from the benefits stream.

where:

c_{it} = the social marginal cost or the opportunity cost of one unit of input i in time t. i=1...v;

a_{ijt} = the minimum required amount of input i to accommodate one student in activity j in time t.

Net benefits of activity j, (Z_j), are thus:

2.2.3 $$Z_j = Y_j - Y_{j'} - C_j$$

and the net benefits of the entire educational system (Z*) comprising m activities are:

2.2.4 $$Z^* = \sum_{j=1}^{m} (Y_j - Y_{j'} - C_j)$$

Throughout this paper the economy is treated as exogenous to the model. The demand functions for educated labor aretaken as given; their position and shape do not depend on the pattern of educational development. Likewise, the cost functions for educational inputs are taken as given.

2.3. The Treatment of Non-Economic Benefits and Costs.

The analysis presented in this essay deals exclusively with the economic benefits and costs of education. It should be stressed that in many cases, allocation of resources to meet non-economic objectives

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11. There are a number of reciprocal relations between the educational system and the economy. For example, the educational system alters patterns of consumption, induces changes in relative wages, and influences the course of technological change and the sectoral distribution of output. These changes in the economy directly affect the demand for various types of educational output, and the supply of inputs used inthe educational system.

is considered by planners or by the public to be more important than economic efficiency.

From both the social and the indivadual standpoint there are a number of political, social, religious, and other non-economic effects of education. The economically efficient patterns of allocation yielded by the model presented below are intended to be one input into the planning process, in competition with other allocation plans based on non-economic considerations. At various points in the essay an attempt will be made to suggest how the results of the model based on purely economic maximization can be useful for policy-making in the presence of non-economic benefits and constraints. However, the function of this approach is not to describe one socially desirable pattern of allocation, but rather to clarify the economic benefits and costs of the educational choices facing a society. Thus, although non-economic considerations often enter as constraints on the maximization process, no attempt will be made to integrate economic and non-economic benefits in the objective function. In the absence of a well-defined social utility function, or planners preference function, final decisions on educational planning must result from the political process.

2.4. An Illustrative Model of the Educational System and the Economy.

The model developed below will serve to elucidate the principle of the efficient allocation of resources with respect to the major educational planning problems presented in section 1.1, namely:

a. the determination of the total resource use by the educational system;

b. the distribution of this total among the different educational institutions or groups of institutions;

c. the choice of productive techniques in each producing unit; and

d. the choice of domestic production versus importation of educated labor.

This illustrative model will serve as the basis for the planning model developed in Chapter 3.

Consider an economy with three sectors, producing consumption goods, labor educated to level 1, and labor educated to level 2. Let there be three factors of production, namely the two types of labor mentioned above, plus uneducated labor.[12]

Let the production functions for the three sectors be:

2.4.1 $$C = f(L_{1c}, L_{2c})$$

2.4.2 $$L_1 = \min\left(\frac{L_{01}}{a_{01}}, \frac{L_{11}}{a_{11}}, \frac{L_{21}}{a_{21}}\right)$$

2.4.3 $$L_2 = \min\left(\frac{L_{12}}{a_{12}}, \frac{L_{22}}{a_{22}}, \frac{L_{02}}{a_{02}}\right)$$

12. In order to allow a geometric presentation of the model, it has been assumed that the uneducated labor is used only as an input into the educational production process. Efficiency conditions derived from a model in which uneducated labor is an input into the consumption goods sector are presented below. The addition of a capital goods sector and the augmentation of the production functions to accommodate inputs of capital would not alter the general results derived below.

where: C = the output of consumption goods;

L_i = the output of laboreducated to level i; i=1...2;

a_{ij} = the minimum requirement of labor of level i to allow one unit of level j enrollment;

L_{ij} = the amount of labor of type i allocated to sector j.

i = 0,1,2

j = 1,2,c

The subscript c refers to the consumption goods sector, the subscript o refers to uneducated labor.

Let the production function for consumption goods be characterized by a non-zero elasticity of substitution between the factor inputs. The a_{ij}'s depend largely on the teacher student ratios in the system. Both educational sectors are complete in that they both draw student inputs from the pool of uneducated labor and complete the educational process within the same sector.[13] The model is addressed to the allocation problem for a single time period; production is assumed to take place instantaneously; and the educational outputs have a working life of one period.

The choice of an aggregate production function embodying non-zero elasticity of substitution between factor inputs is based on the literature cited in note 11, p.6 . The use of fixed coefficients production functions to describe the educational production

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13. Thus there are no flows of continuing students from one level to another.

functions can be defended on two grounds:

a. While considerable substitutability of inputs may in fact be possible from a pedagogical standpoint, many educational administrators think that at any given time the appropriate input coefficients are roughly fixed and insist on a common educational process in all schools of the same type.[14] Conventional ideas on the part of professional educators concerning the relation of specific inputs to the quality of output are very often reflected in government regulations or legal instruments, thus insuring considerable uniformity in the production processes of the individual educational establishments.

b. Allocation decisions in the field of education are often presented as choices between production processes embodying fixed production coefficients.

The problem is to maximize the output of consumption goods subject to constraints on the use of educated labor and a total labor constraint, namely to maximize:

2.4.4a $C = f(L_{1c}, L_{2c})$

subject to:

2.4.4b $(1-a_{11})L_1 - a_{12} L_2 \geq 0$

2.4.4c $-a_{21}L_1 + (1-a_{22}) L_2 \geq 0$

2.4.4d $a_{01}L_1 + a_{02} L_2 \geq 0$

where:

$L_1 = L_{11} + L_{12} + L_{1c}$ = gross production of L_1,

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14. For an analysis of the resistance to changes in the educational production processes written by an experienced educational administrator, see C.E. Beeby, "The Conservatism of Education: Its Meaning for Planners" (Cambridge: Center for Studies in Education and Development, 1965) (Mimeographed.)

$L_2 = L_{21} + L_{22} + L_{2c}$ = gross production of L_2

L_0 = the total amount of uneducated labor available.

Where the production function 2.4.1 has the following properties,

$$\frac{\partial C}{\partial L_{1c}} = f_1 \qquad \frac{\partial f_1}{\partial L_{1c}} = 0 \qquad \frac{\partial f_1}{\partial L_{2c}} = 0$$

$$\frac{\partial C}{\partial L_{2c}} = f_2 \qquad \frac{\partial f_2}{\partial L_{2c}} = 0 \qquad \frac{\partial f_2}{\partial L_{1c}} = 0$$

the maximand is similar to the objective function in chapter 3 (equation 3.2.1). A more plausible set of properties for 2.4.1 is that of $\frac{\partial f_1}{\partial L_{1c}}$ and $\frac{\partial f_2}{\partial L_{2c}}$ are negative but constant.[15]

These properties imply downwards sloping linear demand functions for educated labor. While solution of the maximization problem embodying the resulting quadratic objective function and the linear constraints 2.4.4b to 2.4.4d is possible,[16] the linear formulation of the objective function has been used in the empirical applications of the model, so as to simplify the computational aspects of the problem.

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15. The cross partials are assumed to be zero, as above. This formulation is more consistent with the isoquant depicted in figure 2.4.1.

16. A number of solutions to similar problems are presented in John C. Boot, Quadratic Programming (Amsterdam: North-Holland Publishing Company, 1964). See also Henri Theil, "Linear Decision Rules for Macrodynamic Policy Problems" in Bert Hickman, (ed.), Quantitative Planning of Economic Policy (Washington: Brookings Institution, 1965), pp. 18-42, and the literature cited therein.

Figure 2.4.1 is a geometrical presentation of the model. Inputs are represented as negative outputs, and the length of the production rays is limited by the constraint 2.4.4d.[17] In quadrant IV the production function for L_1 is expressed as a ray from the origin, Ob. The slope of Ob is $-a_{21} / (1-a_{11})$. Thus if $a_{11} = 0$, (i.e. if no level 1 labor is used as teachers in the L_1 production process), the slope of Ob is equal to the negative of the ratio of level 2 teachers to level 1 students. Point b represents the total production of level 1 labor if all available uneducated labor were expended in producing it, and if the level 2 teachers ($a_{21}L_1$) could be obtained.

In Quadrant II, a ray analogous to Ob represents the production function for the education of L_2. The slope Oa is equal to $\frac{-(1-a_{22})}{a_{12}}$. A production possibility schedule can be constructed by connecting a to b. The area defined by Oa'b' is the production possibility set obtainable to the society in the absence of international flows of labor.[18]

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17. The geometry is adapted from Robert Dorfman, Paul A. Samuelson, and Robert M. Solow, Linear Programming and Economic Analysis (New York: McGraw-Hill Book Co., 1958), Pp. 215-224.

18. In order for some configuration of output to be feasible (i.e. for ab to pass through quadrant I), the following condition must be met:

$$\begin{vmatrix} 1-a_{11} & -a_{12} \\ -a_{21} & 1-a_{22} \end{vmatrix} > 0, \text{ or } (1-a_{11})(1-a_{22}) > a_{12}a_{21}$$

Cf. D. Hawkins and H.A. Simon, "Note: Some Conditions of Macro-Economic Stability," Econometrica, Vol. 17, (July-Oct. 1949), pp.245-248. This condition is certainly not violated for any plausible values for the teacher-student ratios.

The isoquants based on the production function 2.4.1 appear in quadrant I.

Conditions for the efficient allocation of resources can now be derived from the model. Let A_{ij} (i=1,2; j=1,2) represent the i^{th} element of row j of $(I-A)^{-1}$, when I is an identity matrix and A is a matrix of the a_{ij} coefficients. A_{ij} is thus the total direct and indirect use of labor of type i required for the delivery of one unit of type j labor to the consumption goods sector.[19] Since:

2.4.5a $\quad L_1 = A_{11}L_{1c} + A_{12}L_{2c}$, and

2.4.5b $\quad L_2 = A_{21}L_{1c} + A_{22}L_{2c}$

we can restate the problem as:

2.4.6a $\quad$ maximize $C = f(L_{1c}, L_{2c})$

2.4.6b $\quad$ subject to $L_0 = a_{01}(A_{11}L_{1c} + A_{12}L_{2c}) + a_{02}(A_{21}L_{1c} + A_{22}L_{2c})$.

The relevant Lagrangean expression is then:

2.4.7a $\quad$ maximize

$$C^* = f(L_{1c}, L_{2c}) - \lambda\,[(a_{01}A_{11}+a_{02}A_{21})L_{1c}+(a_{01}A_{12}+a_{02}A_{22})L_{2c}-L_0]$$

which yields the following efficiency conditions:

2.4.7b $\quad \dfrac{\partial C}{\partial L_{1c}} = \lambda\,[a_{01}A_{11}+a_{02}A_{21}]$

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19. Deliveries of labor to the consumption goods sector correspond to the net output, namely the gross output minus the intra-educational uses of labor.

2.4.7c $$\frac{\partial C}{\partial L_{2c}} = \lambda [a_{01}A_{12} + a_{02}A_{22}]$$

2.4.7d $$[a_{01}A_{11} + a_{02}A_{21}]L_{1c} + [a_{01}A_{12} + a_{02}A_{22}]L_{2c} = L_0$$

Equations 2.4.7 state that the allocation of L_i to the production of consumption goods should be extended until the marginal productivity of L_i (i=1,2) in the consumption goods sector is equal to λ times the total direct and indirect uses of the scarce primary factor in producing an additional unit net output of L_1. λ can be interpreted here as the total effect of an additional unit of uneducated labor on the production of consumption goods or the shadow price of uneducated labor.

Condition 2.4.7 will be fulfilled if, and only if, the economy and educational system operate at a point (e in figure 2.4.I) where the isoquants for the production of consumption goods are tangent to the production possibility frontier for educated labor, namely where:

2.4.8 $$\frac{\partial C}{\partial L_{1c}} \Big/ \frac{\partial C}{\partial L_{2c}} = \frac{a_{01}A_{11} + a_{02}A_{21}}{a_{01}A_{12} + a_{02}A_{22}} = -\frac{dL_2}{dL_1}$$

Equation 2.4.8 expresses the condition that the marginal rate of substitution in the production of consumption goods must be equal to the marginal rate of transformation between level 1 labor and level 2 labor. At e the gross production of labor of types 1 and 2 are $L_1^0L_1$ and $L_2^0L_2$ respectively. Net production is equal to $0L_1$ and $0L_2$ respectively.

It can be shown that the efficient solution requires that the shadow price of labor of type i within the educational system must

2.4.7c $$\frac{\partial C}{\partial L_{2c}} = \lambda [a_{01}A_{12} + a_{02}A_{22}]$$

2.4.7d $$[a_{01}A_{11} + a_{02}A_{21}]L_{1c} + [a_{01}A_{12} + a_{02}A_{22}]L_{2c} = L_0$$

Equations 2.4.7 state that the allocation of L_i to the production of consumption goods should be extended until the marginal productivity of L_i (i=1,2) in the consumption goods sector is equal to λ times the total direct and indirect uses of the scarce primary factor in producing an additional unit net output of L_1. λ can be interpreted here as the total effect of an additional unit of uneducated labor on the production of consumption goods or the shadow price of uneducated labor.

Condition 2.4.7 will be fulfilled if, and only if, the economy and educational system operate at a point (e in figure 2.4.I) where the isoquants for the production of consumption goods are tangent to the production possibility frontier for educated labor, namely where:

2.4.8 $$\frac{\partial C}{\partial L_{1c}} \Big/ \frac{\partial C}{\partial L_{2c}} = \frac{a_{01}A_{11} + a_{02}A_{21}}{a_{01}A_{12} + a_{02}A_{22}} = -\frac{dL_2}{dL_1}$$

Equation 2.4.8 expresses the condition that the marginal rate of substitution in the production of consumption goods must be equal to the marginal rate of transformation between level 1 labor and level 2 labor. At e the gross production of labor of types 1 and 2 are $L_1^0L_1$ and $L_2^0L_2$ respectively. Net production is equal to $0L_1$ and $0L_2$ respectively.

It can be shown that the efficient solution requires that the shadow price of labor of type i within the educational system must

be equal to its marginal productivity in the consumption goods sector. Rearranging the terms of equation 2.4.8, this condition can be expressed:

2.4.9a $$\frac{\partial C}{\partial L_{1c}} = \frac{\partial C}{\partial L_{2c}} \cdot \frac{a_{01}A_{11}+a_{02}A_{21}}{a_{01}A_{12}+a_{02}A_{22}}$$

2.4.9b $$\frac{\partial C}{\partial L_{2c}} = \frac{\partial C}{\partial L_{1c}} \cdot \frac{a_{01}A_{12}+a_{02}A_{22}}{a_{01}A_{11}+a_{02}A_{21}}$$

The righthand side of the equation is the shadow price of i level labor (i=1,2) within the educational system, or its net effect on C, when used in the production of labor educated to level j. The term

$$(a_{01}A_{11}+a_{02}A_{21}) \;/\; (a_{01}A_{12}+a_{02}A_{22})$$

is the negative of the slope of transformation curve ab. Thus where equation 2.4.9 does not hold, for example where

$$\frac{\partial C}{\partial L_{1c}} < \frac{\partial C}{\partial L_{2c}} \cdot \frac{a_{01}A_{11}+a_{02}A_{21}}{a_{01}A_{12}+a_{12}A_{22}},$$

it is clear that a larger output of consumption goods could be obtained through the transformation of level 1 labor into level 2 labor.

In order to allow a geometrical presentation of the model the consumption goods sector has been depicted as using none of the primary factor, uneducated labor. Thus the total resource use by the educational system is given. Analysis of the optimal total resource use by the educational system requires a model in which

2.4.1* $$C = f(L_{1c}, L_{2c}, L_{0c})$$

To simplify the presentation only the resulting efficiency conditions are

presented here, namely that:

2.4.9c
$$\frac{\partial C}{\partial L_{0c}} = \frac{\partial C}{\partial L_{1c}} \cdot [a_{01}A_{11} + a_{02}A_{21}]^{-1} = \frac{\partial C}{\partial L_{2c}} [a_{01}A_{12} + a_{02}A_{22}]^{-1} = \lambda$$

The model has been used so far to derive conditions for the efficient total allocation of resources to education and the optimal distribution of these resources within the educational system. The third major category of planning decisions (cf p.24 above) is the choice of productive techniques. It is clear that the efficient allocation of resources requires a simultaneous solution of the problems concerning the quantum of resources devoted to education, the distribution of resources among the various educational sectors, and the choice of educational technologies. A solution can be obtained within the framework of this model by defining an alternative production process for L_1, say,

2.4.2*
$$L_1^* = \min\left(\frac{L_{01}}{a_{01}^*}, \frac{L_{11}}{a_{11}^*}, \frac{L_{21}}{a_{21}^*}\right)$$

Letting A_{ij}^* represent the i^{th} element in row j of the $(I-A)^{-1}$ matrix incorporating production function 2.4.2* above, we can define a decision rule for the acceptance or rejection of the new technology: when

2.4.10a
$$a_{01}^*A_{11}^* + a_{02}^*A_{21}^* < a_{01}A_{11} + a_{02}A_{21}$$

accept the new technology. The decision rule specifies the choice of the technology in which the direct and indirect uses of the scarce primary factor are minimized. In geometrical terms, the technology (2.4.2*) should be accepted where b*, the terminal point of the production ray

representing the new technology, lies above the existing production possibility frontier, ab. For b* to lie above ab the following condition must be met:

2.4.10b $$\frac{a^*_{01}A^*_{11}+a^*_{02}A^*_{21}}{a_{01}A_{12}+a_{02}A_{22}} < \frac{a_{01}A_{11}+a_{02}A_{21}}{a_{01}A_{12}+a_{02}A_{22}}$$

or the slope of ab' must be less (in absolute value) than ab.[20]

The fourth major category of planning problems referred to above concerns importation versus the domestic production of educated labor. The decision rule in this case if very simple: import educated labor as long as the cost of importing (in terms of the required export of C goods in payment) is less than the marginal productivity of the labor. Where X_i is the cost of importing, one should import level i labor if:

2.4.11a $$\frac{\partial C}{\partial L_{ic}} > X_i$$

or what is equivalent, if:

2.4.11b $$\frac{\partial C}{\partial L_{ic}} = \frac{a_{oi}A_{ii}+a_{oj}A_{ji}}{a_{oi}A_{ij}+a_{oj}A_{jj}} > X_i$$

The expression 2.4.11b states that where the shadow price of i level

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20. Conditions 2.4.10a and 2.4.10b are identical. Where the number of primary factors exceeds 1, a general decision rule must involve consideration of the production function for $\bar{C}$. An optimizing procedure can be used to compare $\bar{C}$, the maximum C obtained using the old technology with C*, C**, etc., the maximum C obtained using a new technology or a combination of new technologies.

representing the new technology, lies above the existing production possibility frontier, ab. For b* to lie above ab the following condition must be met:

2.4.10b $$\frac{a^*_{01}A^*_{11}+a^*_{02}A^*_{21}}{a_{01}A_{12}+a_{02}A_{22}} < \frac{a_{01}A_{11}+a_{02}A_{21}}{a_{01}A_{12}+a_{02}A_{22}}$$

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2.4.11a $$\frac{\partial C}{\partial L_{ic}} > X_i$$

or what is equivalent, if:

2.4.11b $$\frac{\partial C}{\partial L_{jc}} \frac{a_{oi}A_{ii}+a_{oj}A_{ji}}{a_{oi}A_{ij}+a_{oj}A_{jj}} > X_i$$

The expression 2.4.11b states that where the shadow price of i level

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20. Conditions 2.4.10a and 2.4.10b are identical. Where the number of primary factors exceeds 1, a general decision rule must involve consideration of the production function for $\bar{C}$. An optimizing procedure can be used to compare $\bar{C}$, the maximum C obtained using the old technology with C*, C**, etc., the maximum C obtained using a new technology or a combination of new technologies.

labor within the educational system exceeds the cost of importing, i level labor should be imported.[21]

The above efficiency conditions illustrate the concept of economic efficiency in the educational sector used in this essay. The model suggests a number of applications, some of which are developed in part two of this paper. The next chapter presents an elaboration of the basic model which attempts to take into account a number of the complexities of actual planning problems.

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21. In terms of the geometry in figure 2.4.1 the possibility of importation of teachers allows the consideration of solutions in the previously infeasible IInd and IVth quadrants. For example, if teachers with level 2 education can be imported, activity 1 could operate at b and deliver OL_1^m to the consumption goods sector. Solutions involving a temporary deficit for some types of labor may be important in reaching an efficient intertemporal solution.

22. Consideration of a number of limitations of the model will be taken up in section 3.7.

labor within the educational system exceeds the cost of importing, i level labor should be imported.[21]

The above efficiency conditions illustrate the concept of economic efficiency in the educational sector used in this essay. The model suggests a number of applications, some of which are developed in part two of this paper. The next chapter presents an elaboration of the basic model which attempts to take into account a number of the complexities of actual planning problems.

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21. In terms of the geometry in figure 2.4.1 the possibility of importation of teachers allows the consideration of solutions in the previously infeasible IInd and IVth quadrants. For example, if teachers with level 2 education can be imported, activity 1 could operate at b and deliver OL_1^m to the consumption goods sector. Solutions involving a temporary deficit for some types of labor may be important in reaching an efficient intertemporal solution.

22. Consideration of a number of limitations of the model will be taken up in section 3.7.

Chapter 5

A PLANNING MODEL FOR THE EFFICIENT ALLOCATION OF RESOURCES IN EDUCATION

The planning model presented in this chapter is addressed to four basic economic questions involved in educational planning, namely, what amount of society's resources should be devoted to the educational system, what educational technologies should be chosen, how should the total resource use be distributed among various types of educational institutions, and what is the optimal level and composition of the importation of educated labor.

Most of the analysis in this chapter is based on the principal of maximization subject to constraints. It is in this respect that it differs from the planning approaches described in Chapter I. The objective function expresses the contribution of the educational system to future national income. The constraints include the usual resource constraints and additional boundary conditions. The instrument variables available to policy makers include quantitative instruments which allow continuous variation, for example, enrollments and resource use at various educational levels, and qualitative instruments which require discontinuous or institutional changes. Examples of the latter are choices involving educational technology or changes in the structure of the system. The instrument variables have been defined so as to correspond to the actual policy instruments available to most governments.

The model encompasses a number of periods, so as to allow

consideration of the intertemporal interrelations in the educational system. Time is regarded as discontinuous in this chapter; the period used is one year. Educational outputs, as well as most major educational decisions (e.g. enrollments and allocation of resources within the system) occur discontinuously--once every academic year--and educational inputs are generally contracted for a full academic year. Developments during a period represent the implementation of the decisions taken at the beginning of the period. Thus the methodological requirements for the use of period analysis are met.

The discontinuous nature of most educational decision-making makes it possible to operate the model on a sequential basis. If the planning period is n years, the model can be operated in year 0 (the base year) and the results for the years 1...n computed. Only the enrollments and allocations for the year 1 must be acted on at that time, so that at the end of year 1 the model can be operated once more, incorporating new information on either the production processes or the present values of the educational output. The results for the n year period years 2...n+1 can then be calculated, the values of the instrument variables for year 2 acted upon, and the process continued.[1]

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1. Operation of the model in this manner is probably a good reflection of the actual policy-making process which proceeds from year to year rather than on a once-for-all basis for an entire n-year period. In addition it allows the efficient use of new data. A further advantage is that it avoids the necessity of acting on the values of the instrument variables in the later years in the planning period which are presumably sensitive to the somewhat arbitrary terminal conditions. Cf. section 3.5.

The objective function and the constraint equations are presented in sections 3.2 and 3.3. An outline of the structure of the model is presented in section 3.4; and the problem of the terminal and initial conditions is discussed in section 3.5. Section 3.6 is a discussion of the properties of the solutions on the model; and section 3.7 is a review of some of the assumptions employed and limitations of the model.

3.2. The Objective Function

The objective function used in this model is based on the principle of maximization of the present value of the output of all levels of the educational system over a number of time periods. This amounts to maximizing the contribution of the educational system to future (discounted) national income. The objective function is as follows:[1]

3.2.1 $$Z^* = \sum_{j=1}^{m} \sum_{p=1}^{n} X_j^p \, (Y_j^p - Y_{j'}^p - C_j^p)$$

where:

Y_j^p = the present value (discounted to year 1) of the earnings accruing to an output of activity X_j^p;

$Y_{j'}^p$ = the present value (discounted to year 1) of the alternative earnings stream, namely that which would have accrued to the individual had he not received education at activity j.

The present value of benefits is defined as in equation 2.2.2.

C_j^p = the present value of the costs associated with the enrollment of one student in level j in period p. The present value of costs is defined as in equation 2.2.2.

X_j^p = the number of students admitted to level j in period p.[2]

A number of comments are in order. First, the instrument variables, X_j^p, in the model refer to types of educational programs,

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1. Application of the model requires a slightly more complicated objective function incorporating adjustments for dropouts and failures and for the rate of unemployment among school leavers. These adjustments are discussed in Chapter 6.

2. The activity levels are defined in terms of intake rather than output so as to correspond to the major instrument variables actually controlled by most governments.

and would generally include primary, secondary, and post-primary technical schools, several types of teacher training, and university study.[3]

Second, the social time discount rate used to discount the streams of benefits and costs (cf. equations 2.2.1 and 2.2.2) expresses society's or planners' marginal rate of substitution between present and future income. Operation of the model with a positive i does not necessarily imply pure time preference (myopia) but may be justified on the grounds of diminishing marginal utility of income (assuming the society has a positive rate of growth of income) or on the basis of the probability of surviving until the near or distant future.[4] The function of the economist in this respect is not to decide on a correct rate, but to clarify the implications of using various rates and/or to elicit from the relevant political bodies a rate which approximates the relative social valuation of present and future income. As in Chapter 2, it is assumed that i is a constant.

Third, the maximand is concerned with the size, not the distribution of national income. The pattern of educational expenditure

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3. There are a number of interesting possibilities that have not been developed here. Adult education, on-the-job training and other types of education outside of formal school systems could be introduced as activities in the model. Some activities could be disaggregated by course of study (e.g. university study in science and technology as opposed to liberal arts) or by the level of quality of instruction as measured by both the quality of the inputs and the employment opportunities of the outputs.

4. Cf. O. Eckstein, "A Survey of the Theory of Public Expenditure Criteria", in National Bureau Committee for Economic Research, Public Finances: Needs, Sources, and Utilization (Princeton: National Bureau of Economic Research, 1961), pp. 453-60.

may have significant effects both on the size distribution of income and the geographic or ethnic distribution of income. The distribution of income aspect will be assumed to be dealt with via the usual redistributional instruments.

3.3 The Constraints.

Each of the educational activities is characterized by a production function of the type illustrated in equations 2.4.2 and 2.4.3. The production functions 3.3.1 differ from the previous production functions in that the time required to complete the production process is explicitly taken into account. Thus when the production process is s_j years long,

3.3.1

$$X_j^p = \min\left[\frac{X_{1j}^p}{a_{1j}^p}, \frac{X_{2j}^p}{a_{2j}^p}, \ldots \frac{X_{m+q,j}^p}{a_{m+q,j}^p} \ldots \frac{X_{1j}^{p+s_j-1}}{a_{1j}^{p+s_j-1}} \ldots \frac{X_{m+q,j}^{p+s_j-1}}{a_{m+q,j}^{p+s_j-1}}\right]$$

where: X_j^p = the number of students admitted to level j in period p, j=1...m.

X_{ij}^t = the amount of input i devoted to activity j, in period t, j=1...m; i=1...m+q t=1...n, where q is the number of exogenous constraints and m is the number of activities and n is the number of years in the planning period.

a_{ij}^t = the minimum amount of input i required to accommodate one student in activity j in year t.[5]

The constraints are of three types: use of the endogenous

---

5. Where education to level i is a prerequisite for entry into j, a_{ij} is equal to or greater than unity; the input of one student with level j requires the availability of one student with the necessary prerequisites. The coefficient can exceed unity of labor if type i is directly used in the production process j.

resources which are defined in stock terms (i.e. teachers), use of the endogenous resources which are defined in terms of flows (i.e. continuing students), and the use of exogenous resources. The constraint equations are similar in form to equations 2.4.4b and 2.4.4c. Recall, however, that the model presented in Chapter 2 took no account of the following problems:

a. the temporal aspect of the production process and in particular the different lengths of time taken to produce various educational outputs, and

b. the durability of the educational outputs and inputs which gives rise to a stock of teachers available at the beginning of the planning period.

There are three possible uses for the output of any activity: pursuit of further education in the system, employment as a teacher in the system, or employment in the labor force outside of the educational system. These three uses can be referred to as use as an intermediate good, use for capacity creation, and deliveries for final demand. The total requirements for labor of type j within the educational system thus depend on the levels of the activities which use it as a student input, and the required capacity creation in the activities which use it as a teacher. Assume that we have m types of education, j=1...m, and that the activity X_j has a course duration of s_j years. When resource i is defined as a stock, the total required amount of i, time t is then:

3.3.2 $$L^{*t}_i = \sum_{j=1}^{m} \sum_{p=t+1-s_j}^{t} a^t_{ij} X^p_j$$

The righthand side of expression 3.3.2 is the total enrollments in X_j at time t multiplied by the required input of i per student in j, summed over all of the m activities. The total amount of i available in t can be expressed

3.3.3 $$L_i^{*t} = \overline{B}_i^1(1-d_i)^{t-1} + \sum_{p=1}^{t-s_j} g_i X_i^p$$

where :

d_i = the expected annual rate of retirement of the teaching force over the planning period;

g_i = the fraction of the total admissions to activity X_j which is expected to successfully complete the course and to find employment.

For the sake of simplicity it is here assumed that the $d_i=0$ for all outputs of the system during the planning period.[6] The first term in the righthand side of expression 3.3.3 is the total stock of teachers who were in the system in p=0 and who have remained up to p=t. The second term represents the total output of the activity producing resource i since the beginning of the planning period including an adjustment for dropouts and failures.[7] Where input i is defined as a flow, the total required in time t is

3.3.4 $$L_i^{*t} = \sum_{j=1}^{m} a_{ij} X_j^t$$

---

6. Relaxation of this assumption can be easily accommodated within the framework of the model.

7. In the application of the model, the importation of teachers will be presented as an alternative to their domestic production. Thus, a third term in 3.3.3 could represent the total supply of level i teachers from abroad.

and the total available is

3.3.5 $L_i^{*t} = g_i X_i^{t-s_i}$

Where i is defined in stock terms, the constraint that the total requirements of i must not exceed the total availabilities can now be expressed:

3.3.6 $$\sum_{j=1}^{m} \sum_{p=t+1-s_j}^{t} a_{ij}^t X_j^p - \sum_{p=1}^{t-s_i} g_i X_i^p \leq \bar{B}_i^1 (1-d_i)^{t-1}$$

Where i is defined in flow terms the analogous expression is

3.3.7 $$\sum_{j=1}^{m} a_{ij} X_j^t - g_i X_i^{t-s_i} \leq 0$$

The endogenous constraint equations in the model are analogous to equations 3.3.6 and 3.3.7 and are nm in number, namely one per year for each endogenous input.[8]

The constraints on the use of exogenously supplied resources may refer to such inputs as foreign exchange, total social expenditure, and budgetary quantities such as recurrent or capital costs. Where constraints apply to the use of q exogenously supplied inputs the set of nq constraint equations is

3.3.8 $$\sum_{j=1}^{m} \sum_{p=t+1-s_j}^{t} a_{ij}^t X_j^p \leq B_i^t \quad \text{for } i=m+1 \ldots m+q;\ t=1 \ldots n.$$

---

8. Some educational outputs are not used within the educational system. Hence nm is strictly the maximum number of endogenous constraints.

The boundary conditions constraining the maximum or minimum levels which the educational activities can attain may be necessitated for a variety of reasons. Political or legal or administrative constraints may result from a political committment to expand some level of education at a given rate, or because of a limitation of implementing capacity at some level. These boundary conditions may be expressed:

3.3.9 $X_j^p \leq R_j^p$ and/or $X_j^p \geq H_j^p$

where R_j^p and H_j^p are the upper and lower bounds, respectively, for X_j^p.

An important constraint of this type is obviously:

3.3.10 $X_1^p \leq R_1^p$

where R_1^p = the total number of children in the primary entrance age group in period p.

The constraints can never be a precise reflection of the reality which they attempt to represent in the model. The model should be operated a number of times, each time using the shadow prices from the previous year to evaluate the correctness of the levels at which the elements of the constraint vector are set. This approach is developed below, in section 3.6.

three time periods (n=3) and where the durations of course 1 and 2 are 1 and 2 years respectively (s_1=1, s_2=2) is presented in Table 3.4.1 Row 1 of Table 1 is the maximand, rows 2-7 are the endogenous constraints, rows 8-10 are the exogenous constraints. The boundary conditions for upper bounds appear in rows 11-16. The lower bounds are analogous to the upper bounds and are not presented here. Outputs are represented in the system as negative inputs. Both endogenous factors are presented here in terms of stocks.

3.5. Terminal Conditions and Initial Resource Availabilities.

For those periods immediately preceding the end of the plan period, terminal conditions must be developed so that some allowance will be made for intra-educational demand for its own output in the year immediately following the end of the plan period. Were this not done, the system might stop producing teachers and students for pursuit of further studies in the last year or two years of the period. A number of methods of dealing with the terminal conditions is available. The method adopted here is to assume that the activity levels immediately prior to the end of the plan period will be equal to those in the earlier years of the period multiplied by some growth factor.[9]

A problem arises concerning the initial resource availabilities

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9. The choice of terminal conditions is somewhat arbitrary. It should be pointed out, however, that while the last few years in the planning period may be sensitive to the choice, the relevant years are those on which immediate action must be taken. The sequential application of the model suggested in section 3.1 obviates the need for taking action on any but the first year of the plan period.

TABLE 3.4.1

The Structure of the Model.[a]

(for n=3, m=2, q=1, s_1=1, s_2=2, with no lower bounds)

Objective function:							
1.	$Z_1^1X_1^1$	$+Z_2^1X_2^1$	$+Z_1^2X_1^2$	$+Z_2^2X_2^2$	$+Z_1^3X_1^3$	$+Z_2^3X_2^3$	$= Z^*$
Endogenous Constraints:							
2.	$a_{11}^1X_1^1$	$+a_{12}^1X_2^1$					$\leq B_1^1$
3.	$a_{21}^1X_1^1$	$+a_{22}^1X_2^1$					$\leq B_2^1$
4.	$-g_1X_1^1$	$+a_{12}^2X_2^1$	$+a_{11}^2X_1^2$	$+a_{12}^2X_2^2$			$\leq B_1^2$
5.		$+a_{22}^2X_2^1$	$+a_{21}^2X_1^2$	$+a_{22}^2X_2^2$			$\leq B_2^2$
6.	$-g_1X_1^1$	$-g_2X_1^2$	$-g_1X_1^2$	$+a_{12}^3X_2^2$	$+a_{11}^3X_1^3$	$-a_{12}^3X_2^3$	$\leq B_1^3$
7.		$-g_2X_2^1$		$+a_{22}^3X_2^2$		$+a_{22}^3X_2^3$	$\leq B_2^3$
Exogenous Constraints:							
8.	$a_{31}^1X_1^1$	$a_{32}^1X_2^1$					$\leq B^1$
9.			$a_{31}^2X_1^2$	$a_{32}^2X_2^2$			
10.				$a_{32}^3X_2^2$	$a_{31}^3X_1^3$	$a_{32}^3X_2^3$	$\leq B^3$
Boundary conditions							
11.	X_1^1						$\leq R_1^1$
12.		X_2^1					$\leq R_2^1$
13.			X_1^2				$\leq R_1^2$
14.				X_2^2			$\leq R_2^2$
15.					X_1^3		$\leq R_1^3$
16.						X_2^3	$\leq R_2^3$

a. Both endogenous factors are here defined in terms of stocks rather than flows.

total value of the resulting output of the educational system. One interpretation of the dual is that resources should be valued as low as is consistent with the condition that the entire value of output is imputed to the resources (or boundary conditions) used. Thus for every activity which appears in the optimal basis the sign in expression 3.6.2 is a strict equality; for activities not in the basis the inequality holds. The shadow prices u_k (k=1...3mn + qm) represent the total effect on Z* of the availability of one additional resource of type k.

The solutions of the primal and dual of the problem yield a considerable amount of information useful to planners. The solution of the primal indicates the optimal values for the main policy instruments, and in addition can be used to yield decisions on the introduction of new educational technologies or the importation of educated manpower. The shadow prices of the exogenously supplied resources allow the assessment of the optimality of the level at which the constraints are set. Efficiency condition 2.4.9 states that the shadow price of a resource devoted to education must be equal to its marginal productivity in the remainder of the economy. Thus, if it were found, for example, that the shadow price of a given resource, u*, was considerably higher than the estimated marginal productivity of the resource in the rest of the economy, a relaxation of that particular constraint is indicated. The exogenous resource availabilities in the constraint vector can be altered so as to achieve the equalities required by condition

2.4.9c. As long as the cost elements in the net benefits function reflect social (rather than private) marginal costs, the optimal total resource use can also be determined through the operation of the model without exogenous resource constraints. Activities which produce a net social benefit will be undertaken at the maximum level consistent with endogenous resource availabilities.[10] The shadow prices referring to the boundary conditions indicate the opportunity cost (in terms of the reduction in Z*) of the imposition of these constraints. Thus, where the constraint has been imposed for, say, political reasons, the model allows the estimation of the economic loss incurred in the pursuit of non-economic goals.

3.7. Limitations of the Model.

Because the model employs linear constraints and a linear maximand there are relatively few computational problems involved in solving and using the model. However, computational simplicity has been gained through the use of a number of abstractions. The following requirements are particularly important.

First, the amount of input into each activity must be a linear function of the level of that activity. Thus, effects on the level of inputs not linearly related to the level of output are ignored

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10. Both of the above methods have serious shortcomings where the indicated change in total resource use is very large. This is because a substantial redirection of resources towards the educational system, and the resulting major increase in the output of educated labor is likely to affect the opportunity cost of using educational inputs and the marginal productivity of the educational outputs. (Cf. the discussion in section 3.7.)

and economies or dis-economies of scale, of present, must be dealt with step-wise.[11]

Second, the exogenously determined resource availabilities (the elements of the constraint vector) must be expressed as constants and not as a function of any endogenous variable.

Third, the maximand is expressed as a linear function of the m activity levels. This requires that the net benefits parameters, Z_i^p, are not a function of the level of output of any of the activities. Strictly speaking, where f_i represents the marginal productivity of labor with qualification i (Y/L_i) this requires that:

$$\frac{\partial f_i}{\partial L_j} = 0$$

for all j and all i.

Expression 3.7.1 is equivalent to stating that the elasticity of demand for labor is infinite and the cross derivitives of the production functions in the economy are zero.[12] $\left(\frac{f_i}{L_j} \quad i = j \right)$ This assumption is at the opposite extreme from that made or implied by the manpower requirements school, namely that the elasticity of demand for labor is

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11. Cf. S.Chakravarty, "An Outline of a Method for Programme Evaluation", in P.M. Rosenstean-Roden (ed), Capital Formation and Economic Development (London: George Allen and Unwin, 1964), p.44.

12. In the absence of strict conformity with the requirement 3.7.1 approximate constancy of the Zp parameters may result from the interaction of a number of influences, for example, the expansion of the supply of educated labor accompanied by a rightwards movement of the demand curve for educated labor as a result of economic growth and/or technological change. See section 6.2 and Appendix 7.1.

and economies or dis-economies of scale, of present, must be dealt with step-wise.[11]

Second, the exogenously determined resource availabilities (the elements of the constraint vector) must be expressed as constants and not as a function of any endogenous variable.

Third, the maximand is expressed as a linear function of the [illegible] levels. This requires that the net benefits parameters, Z_j^p, [illegible] level of output of any of the activities.

Specifically, where f_i represents the marginal productivity of labor with qualification i (Y/L_i) this requires that:

$$\frac{f_i}{L_j} = 0$$

for all j and all i.

Expression 3.7.1 is equivalent to stating that the elasticity of demand for labor is infinite and the cross derivitives of the production functions in the economy are zero.[12] $\left(\frac{f_i}{L_j} \quad i \neq j\right)$. This assumption is at the opposite extreme from that made or implied by the manpower requirements school, namely that the elasticity of demand for labor is

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11. Cf. S.Chakravarty, "An Outline of a Method for Programme Evaluation", in P.M. Rosenstein-Roden (ed), Capital Formation and Economic Development (London: George Allen and Unwin, 1964), p.44.

12. In the absence of strict conformity with the requirement 3.7.1 approximate constancy of the Z_j^p parameters may result from the interaction of a number of influences, for example, the expansion of the supply of educated labor accompanied by a rightwards movement of the demand curve for educated labor as a result of economic growth and/or technological change. See section 6.2 and Appendix 7.1.

zero.[13] The constancy of the net benefits coefficients further requires that the unit cost of operating each activity does not depend on any of the activity levels. This in turn requires that the supply functions for inputs to the educational processes are highly elastic over the relevant range.

None of these requirements is met exactly in any concrete planning situation. The validity of applying a linear model of the type proposed depends on how closely the assumptions approximate reality in the particular planning situation and on how sensitive the results of the model are to a likely degree of error.[15]

13. A general comment on the linearity of the objective function is presented in Appendix 6.4.

14. For a large number of inputs an absolute maximum limit on the total use of the input has been imposed. In this case the implied supply function is horizontal up to the limit imposed, and vertical thereafter. For some inputs, however, rising cost function has been approximated by the identification of alternate limited sources of supply, each with a constant but different supply price. The aggregate supply function for teachers holding university degrees, for example, is a step function incorporating both domestic and foreign sources of supply.

15. In Appendix 7.1 an attempt is made to test the sensitivity of the model to errors in both the estimation of the parameters and in the theoretical construction of the model.

Appendix 3.1
A Method for the Analysis of Factor Substitution in Production

The linearity of the constraint equations allows a computationally simple solution to the maximization problem presented in equations 3.4.1 and 3.4.2. However, it also requires the assumption that no factor substitution in production is possible. There is considerable justification for this assumption when applied to educational production processes (cf. section 2.4) and its use does not preclude consideration of discrete changes in production techniques. None the less, it does obscure a number of possibilities for continuous substitution between educational inputs. A method for the analysis of these possibilities within the framework of a linear model is presented below, and applied in Section 7.7.

Consider a productive system characterized by two processes (X_1, X_2) producing the same output and using two factors of production (L_1, L_2), which are available in fixed quantities $(\bar{L}_1, \bar{L}_2)$.[16] The production functions are written in the form identical to equations 2.4.2, and 2.4.3, namely:

A3.1.1a $$X_1 = \min\left\{\frac{L_{11}}{a_{11}}, \frac{L_{21}}{a_{21}}\right\}$$

16. The assumption of a single output is not crucial.

A3.1.1b $$X_2 = \min\left\{\frac{L_{12}}{a_{12}}, \frac{L_{22}}{a_{22}}\right\}$$

where: L_{ij} = the amount of factor i devoted to production process X_j

a_{ij} = the minimum amount of factor i required for the output of one unit of j.

X_j = the output using process j.

The problem is thus to maximize the production of X subject to the fixed resource constraints:

A3.1.2 Maximize $X = X_1 + X_2$

subject to:

A3.1.3a $$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} \leq \begin{bmatrix} L_1 \\ L_2 \end{bmatrix}$$

A3.1.3b

The problem is presented geometrically in Figure A3.1.1. The following notation is used:

Oa and Ob are production rays representing processes X_1 and X_2 respectively;

OL_1 and OL_2 represent the resource availabilities; and

OL_2eL_1 is the feasibility set.

The maximum output is obtained by combining vectors Ob and Oa to reach point e.[17]

Now introduce the possibility of factor substitution in the

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17. The statement is obviously not true where one process produces a larger output per unit of input for both inputs.

production of X. Let us assume that a_2^* units of L_2 can be substituted in production for a_1^* units of L_1 without affecting output.[18] If we set a_1^* equal to one, the marginal rate of substitution in production is a_2^*.

In order to accomodate the substitution possibilities we define two new activities: X_3 which "transforms" a_2^* of L_2 into one unit of L_1, and X_4 which "transforms" one unit of L_1 into a_2^* of L_2. There is no production process associated with the transformation activities; they merely redefine a_2^* units of L_2 as being equivalent in production to one unit of L_1, and vice versa. The transformation activities can be thought of as redefining the feasibility set.[19]

The problem can now be written:

cation
A3.I.4 Maximize: X
the p

18. We assume that the [illegible] rate of substitution is identical in the two production proces[illegible]

19. In the practical application of this approach it is plausible to associate with each activity a cost (and perhaps other inputs) which reflect the changes in the productive equipment and/or administrative arrangements necessary to accommodate factor substitution. (See section 7.6.) The introduction of costs adds a note of realism to the treatment and, moreover, avoids the problem of degeneracy which arises where the problem is presented as in equations A3.1.4 and A3.1.5 below. The degeneracy is attributable to the fact that in the present formulation, X_3 and X_4 are not linearly independent. The degeneracy problem can be avoided by:

a. the introduction of costs associated with each activity; or

b. the use of somewhat different marginal rates of substitution in the two activities; or

c. the definition of an artificial constraint vector which renders factor substitution in one direction economically irrelevant.

Approaches (a) and (b) render activities X_3 and X_4 linearly independent; approach (c) allows the elimination of either X_3 or X_4.

subject to:

A3.1.5a, A3.1.5b

$$\begin{bmatrix} a_{11} & a_{12} & -a_{13} & +a_{14} \\ a_{21} & a_{22} & +a_{23} & -a_{24} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \end{bmatrix} \leq \begin{bmatrix} L_1 \\ L_2 \end{bmatrix}$$

20

where:

$$a_{13} = a_{14} = a_1^* = 1$$

$$a_{23} = a_{24} = a_2^*$$

The transformation activities X_3 and X_4 are represented in Figure A3.1.2 by rays Ox and Oz. The slope of both rays is $-a_{24} = -a_{23} = -a_2^*$. The limit to which Ox and Oz can be extended is set by the supply of L_2 and L_1 as indicated by rectangles $\overline{OL}_1fg$ and $O\overline{L}_2hi$. By moving the origin of the previous feasibility set $O\overline{L}_1e\overline{L}_2$ along the rays Oz and Ox the upper right corner (e) describes the frontier of a

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20. Where there are no costs or boundary conditions imposed on the substitution activities, the constraint equations can be reduced to:

$$(a_{11} + a_{21}/a_2^*)\ X_1 + (a_{12}+a_{22}/a_2^*)\ X_2 \leq L_1 + L_2/a_2^*$$

namely, a system in which there is only one factor of production. (However, see equation system A3.1.11 and the treatment of the problem in section 7.6.) In this case the choice of activities is trivial: where $a_{11}+a_{21}/a_2^* < a_{12}+a_{22}/a_2^*$ select activity X_1; where the inequality is reversed, select X_2.

new feasibility set space $OL_1^*kL_2^*$. The new feasibility set does not describe the quantum of resources actually available; it indicates only that the production processes can be operated "as if" the system were endowed with the combinations of resources specified by the coordinates of points along $OL_1^*kL_2^*$.

There are in general now five possible solutions: operation of X_1 and X_3, X_1 and X_2, X_2 and X_4, X_2 and X_3, and X_1 and X_4 although in the case depicted graphically the latter two combinations of activities are clearly not relevant.

The choice of X_1 and X_3 is indicated where:

A3.1.6a

$$a_2^* < \frac{a_{22}-a_{21}}{a_{11}-a_{12}}$$

The left side of expression A3.1.6a is the negative of the slope of the transformation rays; the right hand side is the negative of the slope of the equal product line connecting the points corresponding to equal outputs along rays Ob and Oa.[21] Letting tt represent the equal product line passing through e, the maximum output possible using X_1 and X_2 is Ot, while Ot' is possible using production activity X_1 and transformation activity X_3. Only where

A3.1.6b

$$a_2^* = \frac{a_{22}-a_{21}}{a_{11}-a_{12}}$$

will the use of X_1 with X_2 yield a total output as great as that attained through the use of one production activity and one transformation acti-

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21. a_2^* is the negative of the slope of the feasibility set boundary kL_2^*.

vity.[22]

Solution of the dual of this problem yields shadow price of the resources (u_1, u_2)* which because of the substitution possibilities must also bear a constant relation, namely:

A3.1.7a $u_1 = a_2^*$

or,

A3.1.7b $\frac{u_1}{u_2} = a_2^*$ [illegible] activity [illegible] that

It is clear that wherever $u_1/u_2 > a_2^*$ a greater output can be obtained through the further substitution in production of L_2 for L_1. Strictly speaking, [illegible] ification

Where the range over which substitution is possible is limited, boundary conditions can be imposed on the transformation activities. A diminishing marginal rate of substitution can be accommodated through the use of a series of transformation activities. This possibility is illustrated in the system of equations and Figure A3.1.3 below.

The analysis of a diminishing marginal rate of substitution requires the introduction of two additional tranformation activities X_5 and X_6, where:

X_5 transforms a_2' of L_2 into one unit of L_1, and

X_6 transforms one unit of L_1 into a_2'' of L_2

The new activities reflect a diminishing marginal rate of substitution, i.e.,

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22. Condition A3.1.6b implies that the processes are equally efficient with respect to their inputs of the composite factor, as described in footnote 5, which in turn implies that: $a_{11}+a_{21}/a_2^* = a_{12}+a_{22}/a_2^*$

A3.1.8 $a_2' > a_2^* > a_2''$

Let the original transformation activities be restricted as follows:

A3.1.9a $X_3 \leq \bar{X}_3$

A3.1.9b $X_4 \leq \bar{X}_4$

These boundary conditions reflect the fact that substitution between factors at the marginal rate of substitution implied by A3.1.5 is limited. Substitution beyond the limits imposed by A3.1.9 is possible, but at the rates implied by the processes X_5 and X_6. If in addition we impose boundary conditions on X_5 and X_6 the problem may be presented in the form:

A3.1.10 Maximize $X = X_1 + X_2$

Subject to:

$$\begin{array}{ll}
\text{A3.1.11a} & \begin{bmatrix} a_1 & a_{12} & -a_{13} & a_{14} & -a_{15} & a_{16} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \\ X_6 \end{bmatrix} \leq \begin{bmatrix} \bar{L}_1 \end{bmatrix} \\
\text{A3.1.11b} & \begin{bmatrix} a_{21} & a_{22} & a_{23} & -a_{24} & a_{25} & -a_{26} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \\ X_6 \end{bmatrix} \leq \begin{bmatrix} \bar{L}_2 \end{bmatrix} \\
\text{A3.1.11c} & \begin{bmatrix} 1 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \\ X_6 \end{bmatrix} \leq \begin{bmatrix} \bar{X}_3 \end{bmatrix} \\
\text{A3.1.11d} & \begin{bmatrix} 1 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \\ X_6 \end{bmatrix} \leq \begin{bmatrix} \bar{X}_4 \end{bmatrix} \\
\text{A3.1.11e} & \begin{bmatrix} 1 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \\ X_6 \end{bmatrix} \leq \begin{bmatrix} \bar{X}_5 \end{bmatrix} \\
\text{A3.1.11f} & \begin{bmatrix} 1 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \\ X_6 \end{bmatrix} \leq \begin{bmatrix} \bar{X}_6 \end{bmatrix}
\end{array}$$

where:

$a_{15} = 1$ $\quad a_{16} = 1$

$a_{25} = a_2'$ $\quad a_{26} = a_2''$

This system is presented geometrically in Figure A3.1.3. The figure is identical to A3.1.2 with the exception of the introduction of

A3.1.8 $a_2' > a_2^* > a_2''$

Let the original transformation activities be restricted as follows:

A3.1.9a $X_3 \leq \bar{X}_3$

A3.1.9b [illegible]

These boundary conditions reflect the fact that substitution between factors at the marginal rate of substitution implied by A3.1.5 is limited. Substitution beyond the limits imposed by A3.1.9 is possible, but at the rates implied by the processes X_5 and X_6. If in addition we impose boundary conditions on X_5 and X_6 the problem may be presented in the form:

A3.1.10 Maximize $X = X_1 + X_2$

Subject to:

$$\begin{array}{ll}
\text{A3.1.11a} & \begin{bmatrix} a_1 & a_{12} & -a_{13} & a_{14} & -a_{15} & a_{16} \end{bmatrix} \\
\text{A3.1.11b} & \begin{bmatrix} a_{21} & a_{22} & a_{23} & -a_{24} & a_{25} & -a_{26} \end{bmatrix} \\
\text{A3.1.11c} & \begin{bmatrix} & & 1 & & & \end{bmatrix} \\
\text{A3.1.11d} & \begin{bmatrix} & & & 1 & & \end{bmatrix} \\
\text{A3.1.11e} & \begin{bmatrix} & & & & 1 & \end{bmatrix} \\
\text{A3.1.11f} & \begin{bmatrix} & & & & & 1 \end{bmatrix}
\end{array}
\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \\ X_6 \end{bmatrix}
\leq
\begin{bmatrix} \bar{L}_1 \\ \bar{L}_2 \\ \bar{X}_3 \\ \bar{X}_4 \\ \bar{X}_5 \\ \bar{X}_6 \end{bmatrix}$$

where:

$a_{15} = 1$ $\quad a_{16} = 1$

$a_{25} = a_2'$ $\quad a_{26} = a_2''$

This system is presented geometrically in Figure A3.1.3. The figure is identical to A3.1.2 with the exception of the introduction of

activities Or and Oq which represent X_5 and X_6 respectively. The lengths of Ox and Oz are determined by the constraint equations A3.1.11c and A3.1.11d. Because X_5 and X_6 are less efficient than X_3 and X_4 respectively,[23] X_5 will not be introduced into the optimal basis unless constraint equation A3.1.11c is active, and analogously for X_6. This condition allows the presentation of Or as originating at the terminal point of Ox, and Oq at the terminal point of Oz. The feasibility set $OL_1' mnep L_2'$ is constructed as in Figure A3.1.2 by moving the factor endowments space $O\bar{L}_1 e \bar{L}_2$ along the transformation rays.

Production will take place as if the resource combinations defined by the vertices L_1', m,n,p, and L_2' were available. If $a_2' > \frac{a_{22}-a_{21}}{a_{11}-a_{12}} > a_2^*$, for example, production will take place at n, with production activities X_1 and X_2, and transformation activity X_3 run at positive levels, and the constraints on the use of L_1', L_2', and the boundary condition on X_3 active.

The method has been presented here in general terms, and it is possible that it may find general application outside of the field of educational economics. One of the many possible applications to the problem of educational planning is developed in Section 7.6.

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23. This condition arises from relation A3.1.8.

CHAPTER 4. THE STRUCTURE OF THE MODEL

4.1. Introduction.

The remaining chapters represent the application of the model described above to some economic aspects of educational planning in the Northern Region of Nigeria.

The present chapter contains an initial section demonstrating the economic importance of education in Northern Nigeria as a user of scarce resources. This is followed by an outline of the structure of the educational system, and a brief account of recent planning efforts. Problems concerning the structure of the model as applied to Northern Nigeria occupy the remainder of the chapter.

4.2. The Magnitude of Educational Expenditures and Employment.

The educational establishment is a major sector of the Northern Nigerian economy. In 1964 it was the largest single employer of labor with a post primary education and probably accounted for almost half of the total demand for educated labor.[1] In addition the educational system enrolled 476,934 students, many of whom would otherwise have joined the labor force.[2]

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1. Federation of Nigeria, National Manpower Board, Nigeria's High-Level Manpower, 1963-70 (Lagos: Ministry of Information, 1964), Tables 6 and 7; Government of Northern Nigeria, Ministry of Education, Classes, Enrollments, and Teachers in the Schools of Northern Nigeria (Kaduna: Government Printer, 1964).

2. The total number of teachers employed in 1964 was 15,585. These figures do not include Amadu Bello University. Cf. Ministry of Education, Classes, Enrollments, and Teachers.

Government expenditure on education has constituted a major portion of the total government budget; during the period 1954-55 to 1962-63 recurrent expenditure by the Ministry of Education accounted for an average of 19 percent of the total. The Ministry of Education was by far the largest spending ministry in every fiscal year.[3] The proposed expenditure on educational projects in the Northern Nigeria Development Plan, 1962-68 is 19.9 million or 21 percent of the planned total capital expenditure over the period. It is considerably larger than road development and agriculture, the two other significant expenditure categories.[4]

It is important to note that despite the large expenditure of resources on the educational system, Northern Nigeria remains one of the most educationally backward areas in the world. The Ministry of Education estimates that in 1964 only 11 percent of the primary school age group were in school, and the enrollment ratios for post-primary education are much lower.[5]

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3. Government of Northern Nigeria, The Accountant General, Report, 1954-5 to 1962-3 (Kaduna: Government Printer, n.d.).

4. Government of Northern Nigeria, Development Plan, 1962-1968, Project List as at 31st March, 1964 (Kaduna: Government Printer, n.d.). For the breakdown of major expenditure groups in the development plan see Appendix 4.1.

5. Jefferson Eastmond, "A Progress Report on Efforts to Attain the Enrollment Goals of Primary Education in Northern Nigeria" (Kaduna: Ministry of Education, July, 1964). (Mimeographed.) This figure is computed on the basis of the 1963 census, the accuracy of which is still open to some question. Enrollments in the first year are about 14.5 percent of the 6 year old age group. Of the 200 territorial units listed by UNESCO in its 1963 Statistical Yearbook (Paris: UNESCO, 1964), only the following 12 exhibited lower primary school enrollment ratios: Angola, Ethiopia, Gambia, Mali, Mauritania, Niger, Somalia, Upper Volta, Afghanistan, Nepal, Saudi Arabia and Yemen.

4.3. The Structure and Development of the Educational System of Northern Nigeria.

The structure of the educational system is depicted in Table 4.3.1. The table has been arranged so that all of the student flows fall above the diagonal, while all the teacher flows fall below it.

An outline of the content of the various courses is given below. The primary school course of studies concentrates on teaching language skills including literacy in English, skills and knowledge necessary for constructive political participation, some work directed towards developing vocational skills (chiefly rural science and crafts), and preparation for post-primary education. At the successful completion of the course students are awarded the Certificate of Primary Education, and may compete in the Common Entrance Examination for places in post-primary institutions.[6] The craft schools offer a course in general secondary education with emphasis on subjects which will raise the students' level of technical trainability. The secondary grammar schools present a course in general education leading to the West African School Certificate, which is awarded on the basis of successful competition in an external exam. The elementary teachers certificate (grade III) course is offered at teacher training colleges, and concentrates on general subjects, with some specialization in the subjects

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6. The term "school leaver" is applied to the outputs of most educational institutions. The word "graduate" is reserved for those who successfully complete the university course.

TABLE 4.3.1. The Educational System of Northern Nigeria.[a]

Producing Sectors	USUAL AGE OF ENTRY	DURATION OF COURSE IN YEARS	Using Sectors 1	2	3	4	5	6	7	8	9	LABOR MARKET
1. PRIMARY SCHOOL	6	7		S	S	S						L
2. CRAFT SCHOOL	13	3						S				L
3. GRADE III TEACHER'S COURSE (TEACHER TRAINING COLLEGE)	13	3	T	T			S					
4. SECONDARY SCHOOL	13	5							S	S		L
5. GRADE II TEACHER'S COURSE (TEACHER TRAINING COLLEGE)	16	2	T	T	T	T	T					
6. TECHNICAL TRAINING SCHOOL	16	3										L
7. FORM VI	18+	2									S	L
8. NORTHERN SECONDARY TEACHER'S COLLEGE (N.S.T.C.)	18+	3	T	T	T	T	T	T				
9. UNIVERSITY STUDY	18+	3			T	T	T	T	T	T		L

a. Flows which have not been represented in the model have been excluded from this Table.

KEY.

T indicates a flow of teachers.

S indicates a flow of students.

L indicates a flow of school leavers to the labor market.

which the future teacher will endeavor to teach, and some training in pedagogical technique. The higher elementary teacher's certificate (grade II) course is similar except that it proceeds at a more advanced level.[7] The technical training schools offer 3 year courses in such trades as carpentry and joinery, motor mechanics, sheet metal work, electrical installation, plumbing, and brick-laying. Upon successful completion of the course the student receives a Government of Nigeria Craft Training Certificate, which is equivalent to passing the Government Trade Tests for Artisans Grade III and II. The sixth forms offer a two-year university preparatory course for secondary school leavers. Students generally specialize in three of a large number of academic disciplines chosen from the liberal arts or sciences. Successful students receive a Higher School Certificate which, if the student has done well, will gain him admission to a university. Most university entrants in Nigeria hold the Higher School Certificate, or its rough equivalent, the General Certificate of Education (Advanced Level). For these students the university course will normally extend over three years. Some universities allow admission to a 4-year course to outstanding students

7. In 1962-3 the grade III course was made an integral part of the gradeII course and the intention to cease training any more grade III teachers was expressed by the Ministry of Education. The first 3 years of the integrated course are to be devoted to general education with specialization and pedagogical training being confined to the last 2 years. The courses are defined here as separate activities because significant numbers continue to leave at the end of three years upon receipt of the grade III certificate, and the last 2 years of the now integrated course still draw student inputs from the teaching force. Thus, there continues to be a definite structural discontinuity in the course.

holding a West African School Certificate or its rough equivalent, the General Certificate of Education (Ordinary Level). The Northern Secondary School Teachers College (also referred to as Higher Teacher Training College) offers rather specialized training in the future teachers' prospective field, and courses in pedagogical technique and the psychology of learning. Teachers trained in this course are expected to teach in primary schools and other post-primary institutions as well as in secondary schools. Successful students receive the Nigerian Certificate of Education (NCE).

The first major effort to write a consistent and comprehensive plan for Nigeria's educational development was initiated in 1960.[8] A group of American, British and Nigerian educators under the chairmanship of Sir Eric Ashby was asked to study the post-secondary school educational system of Nigeria and to make recommendations for its future development. This "Commission on Post-School Certificate and Higher Education in Nigeria" (the Ashby Commission) asked Professor Frederick Harbison to do a study of Nigeria's requirements for high level manpower over the decade 1960-1970 to provide the quantitative basis for the Ashby Commission's work. Harbison based his "manpower targets" on the very meagre information on the Nigerian labor force and economy available at the time and on assumptions concerning the future rate of growth of the economy,

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8. No attempt will be made here to give a detailed account of the planning process, or to include material which is not directly relevant to the problems raised in the following chapters.

the levels of inputs of labor of various types into each productive sector and the expected rate of retirement from the labor force among some groups of labor. The Ashby Report along with Harbison's report have become the basis of formal educational planning in Nigeria.[9]

Because the Ashby Report contained virtually no cost information and was insufficiently disaggregated both regionally and temporally, the Federal Government in late 1960 asked Mr. J.N.Archer to develop a regionally disaggregated and phased pattern of enrollments over the period 1961-70 consistent with the Ashby recommendations, and to estimate the costs of the resulting plan. The section of the Archer Report dealing with the Northern Region, along with the "White Paper on Educational Development in Northern Nigeria, 1961", the Estimated Capital Expenditures-1962-67" (Ministry of Education, Northern Region) and the section of education in the Northern Nigeria Development plan embody the educational plans of the government.[10]

9. The Ashby Report was published as: Investment in Education, the Report of the Commission on Post School Certificate and Higher Education in Nigeria (Lagos: Ministry of Education, 1960). Professor Harbison's report is published in the same volume under the title "High Level Manpower for Nigeria's Future," pp.50-73. Given the circumstances, it was inconceivable that both of the above reports should not contain a number of shortcomings. A thorough critique of both would be a valuable addition to the literature on educational planning, but it would be considerably outside the scope of this paper.

10. J.N.Archer, Educational Development in Nigeria 1961-70, A Report on the Phasing and Cost of Educational Development on the Basis of the Ashby Commission's Report, (Lagos: Government Printer, 1961); Government of Northern Nigeria, White Paper on Education Development in Northern Nigeria, 1961 (Kaduna: Government Printer, 1961); Government of Northern Nigeria, Ministry of Education, "Estimated Capital Expenditures 1962-1967," Circular F2727/14 of 7.2.61. (Mimeographed.); "Northern Nigeria Development Programme, Section VIII," Federation of Nigeria, National Development Plan, Ch.VII, 1962-8 (Lagos: Government Printer, 1962). Appendix 7.2 presents a comparison of the enrollment targets of the present government plans with the results yielded by the planning model described in Chapter 3.

4.4. Implementation of the Model: Scope and Structure.

4.4.1 The Geographical Scope. Before estimating the parameters of the model, a number of decisions on the scope of the model and the methods of aggregation to be used had to be made. The first major decision concerned the geographical scope of the model. Control of enrollments and allocation of resources in Nigerian education is primarily in the hands of the four regional governments. With the exception of higher education, jurisdiction over the entire educational system in Nigeria is given by the constitution to the regional governments.[11]

The model has been constructed to reflect the fact that the locus of educational decision-making is the regional capital. The policy questions asked are those facing the regional government, the instrument variables are defined in terms of regional enrollments and resource use, and the constraints are defined in terms of regional resource availability. It was decided to estimate the model for Northern Nigeria because of the quality and availability of the economically relevant educational data, and because of the degree of control which the Northern government exercises over enrollments, and allocation of

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11. Although jurisdiction over higher education is shared by the regional and federal governments, the regional governments of the universities themselves have exercised most of the decision-making influence in this area. There are indications that the federal government's participation in university affairs will increase over the next few years.

of resources in education.[12]

4.4.2. The Temporal Scope. The choice of 1964 as the base year for the model was dictated by the breadth and quality of the data for that year. The question to which the model is addressed is: given the information available to planners in late 1963,[13] what should be the values of the instrument variables for an eight year planning period commencing in 1964?[14] Although the model has been operated only for years 1964 to 1971, the model is intended to be run sequentially (cf. 3.1.), with the base year moving forward and new information being incorporated from year to year.

4.4.3. The Choice of Factors. The factors of production considered explicitly in the constraint equations of the model are those for which the elasticity of substitution with other factors is low. The inputs considered (with the appropriate subscripts) are listed below:[15]

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12. My greater familiarity with the North also entered into the decision to concentrate there.

13. Much of the data used in the model was not actually available in 1963, but with very few exceptions it could have been. The 1964 cost data and the teacher input data presumably reflect government policy made and therefore available in 1963.

14. Most approaches to educational planning use a longer time period. The choice of eight years was taken on the grounds that there is considerable slack in the education system (i.e. each level enrolls a small percentage of the output of the next lower level) and for this reason a planning period only as long as the longest unbroken production process was required. A planning period this long allows the model to explicitly present all of the intereducational flows of students and teachers. When the model is operated on a sequential basis, as suggested below, there is no gain in using a longer period.

15. The definition and estimation of the input coefficients is discussed in chapter 5.

Endogenous Inputs:

1. primary school leavers
2. craft school leavers
3. grade III teachers
4. secondary school leavers
5. grade II teachers
7. Form VI leavers
8. Nigerian Certificate of Education (NCE) teachers
9. university graduate teachers

Exogenously supplied inputs:

10. total social expenditure
11. senior university teachers (input only into university activities)
12. children of the 6 year age group (input only into primary school activity.

4.4.4. The Choice of Activities. In 1964 the educational system consisted of 2825 separate formal educational institutions, many of them with a variety of distinct courses, plus a large number of Koranic schools, inservice training programs, and master-apprentice relationships.[16] The individual producing units are grouped into aggregates ("courses") so as to minimize the internal differences in the input structure and the

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16. Ministry of Education, Classes, Enrollments and Teachers.

economic nature of the output.[17]

The criteria for the inclusion or exclusion of courses is as follows. First, the course has to be long enough to make medium range planning necessary. Short courses, the prerequisites for which are in large supply relative to any plausible level of the course's intake, are excluded. These brief courses can be expanded or contracted as the supply and demand for their outputs warrants.[18] Second, data on the course have to be available or within the capacity of the researcher to generate. Third, the course has to have some significant effect on the economic behavior of its products. On the basis of these criteria the following courses have been excluded from the model: the Koranic schools, master-apprentice relations, on-the-job training programs, and the Technical Institute of Kaduna.

The producing activities used in the model are identical to the set described in Table 4.3.1; the numbers in the far left hand column of that table refer to the j subscripts used. Each type of education is represented by an activity in each of the 8 years of

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17. These criteria are the standard ones for aggregation in interindustry analysis. Cf. Hollis B. Chenery and Paul G. Clark, Interindustry Economics (New York: John Wiley and sons, 1959), pp.34-9, and Robert Dorfman, et.al., Linear Programming and Economic Analysis, p.242. The activities in this model closely correspond to the original Leontief formulation of an industry; they have homogeneous outputs and similar input structures. Because of the well defined boundaries between types of educational institutions, and the uniformity of curriculum and required level of inputs, a degree of homogeneity in aggregation is possible when dealing with the education system which may be impossible when dealing with the economy.

18. This approach is suggested in J. Tinbergen, Educational Planning Handbook, UNESCO, 1964, Chapter 5, p.1,(mimeo.)

the planning period. The activities, X_j^p, are defined as the total intake of students in time p into activity j.

Two activities in the model allow the movement of factors into the educational system:[19]

X_{10} = Import one university graduate teacher

X_{11} = Import one well qualified non-graduate (equivalent to an NCE teacher)

The use of these or similar activities allows the computation of a solution that is optimal with respect to internal allocation of a given set of factors as well as the total use of the factors. These particular activities were chosen because of the importance of policy questions involving the use of foreign teachers.

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19. The structure of these activities is described in more detail in Chapter 5.

Appendix 4.1 Educational and Other Expenditures in the Northern Development Plan

Table A4.1.a

Planned Capital Expenditures in the Northern Region Development Plan, 1962-8

Field	Total in million £
Education	19.9
Agriculture	16.3
Animal & Forest Resources (Livestock)	4.3
(Forest)	.5
Trade & Industry	1.1
Road Development	19.5
Urban Water Supplies	4.7
Rural Water Supplies	3.0
Works (Administrative Projects, etc.)	1.6
(Social Sector)	.2
Health	3.7
Social Welfare	3.3
Co-operatives	2.0
Land and Survey	3.0
Information	.4
Administrative Buildings	1.0
Justice	*
Internal Affairs	*
Finance (Social Sector)	2.0
(Development Sector)	8.7
Total	95.2

* Indicates a figure less than £100,000.

Source: Northern Nigeria Development Plan, 1962-8 Project List as at 31st March, 1964. Educational Projects falling under other ministries have been allocated to the education field, as shown in Table A4.1.b.

Table A4.1.5

Educational Projects in the Northern Region
Development Plan, 1962-8

in £'s

1.	Projects falling directly under the Ministry of Education:	16,103,752
	Allocated as follows:	
	Teacher Training 4,125,865	
	Technical Education 2,991,791	
	Islamic Education 295,500	
	Primary Education 2,385,901	
	Secondary Education 6,189,695	
	Other Minor Projects 115,000	
2.	Ahmadu Bello University	2,080,690
3.	Training of Personnel and other Educational Projects in the following Ministries:	
	Agriculture	669,570
	Animal and Forest Resources	93,000
	Health	665,880
	Cooperatives	11,000
	Land and Survey	820
	Establishments and Training	66,750
	Internal Affairs	257,150
	Total:	19,948,612

Source: Northern Nigeria Development Plan, 1962-8 Project List as at 31st March, 1964.

CHAPTER 5. THE PRODUCTION OF EDUCATION

5.1. The Conceptual Framework.

There is an observable relationship between the factor inputs and the levels of student intake and output in Northern Nigerian educational institutions. The existence of this relationship allows the estimation of production functions for the various types of education described in Chapter 4.[1]

A production function for education expresses a relationship between the activity level of the type of education concerned and the necessary quantum of inputs. When we say that:

5.1.1. $X_j = f(X_{ij}, \ldots X_{mj})$

we express the maximum enrollment of students at level j which can be accommodated with any given quantum of inputs $(X_{ij} \ldots X_{mj})$. This relation is partly technological in that the inputs described as necessary are the minimum amounts thought to be compatible with producing the capabilities associated with the level of education in question. It may also be definitional or institutional; to some educators the nature of the output is defined by the quantum of various inputs,[2] and in some institutional

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1. In this chapter I will confine the discussion to production functions actually in use or likely to be used over the planning period. The introduction of new production functions is discussed in Chapter 7.

2. The input of a 15-year old student plus some quantity of teachers holding university or teachers' college degrees to a production process lasting five years produces a product called secondary education. If the inputs are changed by adding five years to the age of the student inputs and graduate degrees to the teaching inputs, the product becomes "higher education."

of providing housing for indigenous teachers.[3]

The only major item of social cost not included in the money costs was the opportunity cost of withholding labor from the labor force during the course of education.[4]

The building cost attributed to the students educated during the planning period is based on a depreciation charge plus an interest charge on the capital cost per student place.

Table 5.1 presents the basic cost figures along with the adjustments described in the above two paragraphs.

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3. Hiring foreign teachers for the educational system imposes housing costs on the society which would not have occurred otherwise. This [illegible] of Nigerian teachers.

Strong arguments can be made for excluding the costs of [illegible]ing and maintaining student dormitories. Cf. Schultz, The Economic Value of Education, p.25. To the extent that these arguments are valid, my estimates overstate the real social cost of education.

4. It will be recalled that the objective function is constructed to reflect this cost. Cf. equations 3.2.1. and 2.2.1.

of providing housing for indigenous teachers.[3]

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Table 5 presents the basic cost figures along with the adjustments described in the above two paragraphs.

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3. Hiring foreign teachers for the educational system imposes housing costs on the society which would not have occurred otherwise. This [illegible] of Nigerian teachers.

[illegible] arguments can be made for excluding the cost of [illegible]ng and maintaining student dormitories. Cf. Schultz, The Economic Value of Education, p. 25. To the extent that these arguments are valid, my estimates overstate the real social cost of education.

4. It will be recalled that the objective function is constructed to reflect this cost. Cf. equations 3.2.1. and 2.2.1.

a. Column 2 represents the adjustment of Column 1 for the divergence between total costs borne by the institutions and social costs. See Appendix 5.1.

b. Column 3 is the total capital cost per student place, excluding those items of capital cost which are not directly accomplished by the process of education (e.g. housing indigenous teachers). See Appendix 5.1.

c. The estimated value of the services of plant and equipment consumed per student per year is based on a straight line depreciation method and an assumed length of life of 30 years.

d. The interest charge is Column 3 multiplied by .05.

e. Figure in parentheses applies to the first year of the comparison and includes round trip air fares.

Source: See Appendix 5.1.

The costs of producing the additional teachers required for the enrollment levels yielded by the model cannot be attributed entirely to those teacher services produced within the planning period, as the working life of the teacher is considerably longer than the eight-year period used in the model. Allowance is made for the fact that the society is endowed with a larger stock of teachers at the end of the planning period than at the beginning and that these teachers will continue to produce education over their working lives. The method adopted here is to estimate the working life of the teacher and then to allocate to the costs of the planning period a fraction of the costs of teacher training based on s, the total years of teaching performed within the planning period, and q, the total length of working life, from graduation to retirement. Because the net benefits derived from the existence of the stock of teachers in the distant future are valued less highly than those at the present or near present (assuming a positive social time preference) this understates the fraction of the present value of the lifetime benefits which the teacher will produce within the planning period. The fraction of the present value of the benefits stream occurring within the planning period for a teacher whose training commences in period p may be approximated by $_{s}p$, where:

$$_{s}p = \frac{\sum_{t=p+a}^{t=p+s} (1+i)^{-t}}{\sum_{t=p+a}^{t=p+q} (1+i)^{-t}}$$

and s = the length of the teacher training course in years

i = the rate of social time discount

p and q are defined as above

Where i = 0 the expression 5.2.1 is equal to s/q

5.3 **The Teacher Input Coefficients.**

The coefficients referring to teacher inputs were estimated on the basis of actual 1964 data, some projections of future coefficients based on historical trends and direct information concerning the planned movement of the coefficients over time.

Systematic changes in the input coefficients over time can be assumed to represent the implementation of government policy concerning the educationally desirable composition of the teaching staff. There is considerable evidence that variations in a series of some such can be satisfactorily explained by time. Where a regression of the

---

5. In the case of a teacher whose training commences in period p, and is a 9-p-s. The values of PV used in estimating the costs of the teacher training activities appear in Table A5.2.

6. An alternative to this method would be to assign a value to the increment in the stock of teachers and to add terms representing the present value of the increment in the stock of teachers to the objective function. The valuation of the teacher stock could be done exogenously, or on the basis of shadow prices of the teachers in question yielded by previous solutions of the model. The successful use of shadow prices would probably require several iterations.

7. No adequate time series of per student cost is available. Increased economy in building will probably be offset by the improvement in the composition of the teaching staffs (shifting towards more expensive teachers) and an upward movement in the age structure (and hence the pay) of the teaching staff. The net effect may be an increase in cost.

his[torica]l [ser]ies of a_{ij}'s on time yielded a satisfactory prediction equat[ion] the future movement of the a_{ij}'s was estimated on this basis. [Some] were based on direct information concerning the government's [in]tentions to alter the teacher input coefficients where this information [was] available and credible.

The a_{ij}'s estimated over the planning period are presented in Table 5.3.1. The historical data on the a_{ij}'s and the basis for estimation of the a_{ij}'s appearing in Table 5.3.1 appears in Table AS.1.1a and b respectively [in] Annex 5.1.

The improvement in the composition of most teaching staffs can be seen in the increase in the value of the coefficients applying to relatively well-qualified staff (NCE at all levels, and grade II in the primary schools) and a decline in the relatively less well-qualified staff.[8]

Changes in the a_{ij}'s can be considered analogous to disembodied technological change--the effects apply throughout the system in new and old capacity alike. Thus the demand in period t for teachers of qualification i in level j depends on two elements: the enrollments at activity j and the input coefficient. Letting T^p_{ij} equal the demand in period p for teachers of qualification i in activity j, and $\bar{X}^p_j$ equal the total enrollments in activity j in period p, then

5.3.1 $T^p_{ij} = a_{ij} \bar{X}^p_j$

---

8. Graph 5.3.1 illustrates this process of upgrading of the teacher input coefficients for the primary school system.

(3.3)

The Movement of the Teacher Input Coefficients Over Time

	1964 (Actual)	1965	1966	1967	1968	1969	1970	1971
				(projected)				
Inputs into Primary								
NCE Teachers (a_{81})	.00021	.00023	.00025	.00028	.00031	.00035	.00039	.00043
Grade II Teachers (a_{51})	.00546	.00609	.00657	.00709	.00765	.00825	.00889	.00957
Grade III Teachers (a_{91})	.01257	.01217	.01192	.01162	.01128	.01089	.01046	.00999
Inputs into Craft School								
NCE Teachers (a_{82})	.01563	.01650	.01700	.01775	.01850	.01925	.02000	.02063
Grade II Teachers (a_{52})	.01771	.01771	.01771	.01771	.01771	.01771	.01771	.01771
Grade III Teachers (a_{92})	.00104	-	-	-	-	-	-	-
Inputs into T.T.C.'s III								
Graduate Teachers (a_{93})	.02085	.02085	.02085	.02085	.02085	.02085	.02085	.02085
NCE Teachers (a_{83})	.01827	.01928	.01987	.02074	.02162	.02250	.02337	.02411
Grade II Teachers (a_{53})	.00941	.00297	-	-	-	-	-	-
Inputs into Secondary Grammar								
Graduate Teachers (a_{94})	.03090	.03090	.03090	.03090	.03090	.03090	.03090	.03090
NCE Teachers (a_{84})	.00657	.00695	.00714	.00746	.00777	.00809	.00840	.00867
Grade II Teachers (a_{54})	.00598	.00243	.00110	-	-	-	-	-

	1964 (actual)	1965	1966	1967	1968	1969	1970	1971
Inputs into T.T.C.'s II								
Graduate Teachers (a_{95})	.02085	.02085	.02085	.02085	.02085	.02085	.02085	.02085
NCE Teachers (a_{85})	.01827	.01937	.02074	.02142	.02250	.02357	.02411	
Grade II Teachers (a_{55})	.00942	.00851						
Inputs into Technical Training Schools								
NCE Teachers (a_{86})	.01388	.01388	.01388	.01388	.01388	.01388	.01388	.01388
Graduate Teachers (a_{96})	.00694	.00694	.00694	.00694	.00694	.00694	.00694	.00694
Inputs into Form VI								
Graduate Teachers (a_{97})	.08332	.08332	.08332	.08332	.08332	.08332	.08332	.08332
Inputs into NSTC								
Graduate Teachers (a_{99})	.06666	.06666	.06666	.06666	.06666	.06666	.06666	.06666
Inputs into Universities								
Senior University Teachers ($a_{11,9}$)	.05546	.05546	.05546	.05546	.05546	.05546	.05546	.05546

Source: see Appendix 5.1

The total demand for teachers of type i in period p, (T_i^p) is:

5.3.2. $$T_i^p = \sum_{j=1}^{m} T_{ij}^p$$

and the total available stock of these teachers is:

5.3.3. $$\sum_{t=1}^{p-s_i} X_i^t + X_{fi}^p + b_i^p$$

where:

X_i^p = the total enrollment of students in course i in time p, i = 1...m;

m = the number of activities;

X_i^t = admission of students to teacher training course i in time t;

X_{fi}^p = the imports of foreign teachers of type i in time p;

T_i^p = the total demand for teachers of type i in period p;

s_i = the length of course i in years;

b_i^p = the estimated stock of teachers of type i surviving from the base year.

5.4. The Educational Product Mix.

The fact that not every student input successfully completes his course of studies has several implications for the structure of the model.

The output of the educational activities in the model can be described in terms of a fixed product mix for a course of s_i years.

The available historical evidence indicates no significant change in the [illegible] of any activity in the model. If present efforts to reduce [illegible] are successful, my estimates of product mix will understate the benefits associated with the relevant educational activities.

duration there are generally $s_j + 1$ products, namely students who leave after each of the years $1 \ldots s_j - 1$, and those who enter the final year respectively fail or pass the terminal examination. Because of the differences in labor force participation rates between sexes, the outputs of some levels have been disaggregated by sex as well as year of leaving the system. Table 5.4.1 presents the product mix, categorized by general type of output (e.g. pass, fail, dropout) and adjusted for relatively low labor force participation rates by female students, and for the unemployment of primary school leavers. Analogous data for the unadjusted are presented to facilitate estimation of the objective function coefficient for primary education. The basic data on which Table 5.4.1 is based appears in Tables A5.4.1 and A5.4.2.

The effect of wastage on the input structure is relatively minor. In the present institutional set-up, the teaching inputs are proportional not to the number of students actually attending at any given moment, but to the number of students originally admitted.[10] The only major reduction in costs occasioned by the dropouts is in the recurrent costs for non-educational purposes (food, etc.).[11]

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10. This is a reflection of the fact that classes are organized in groups of a given number of students, and as that number falls, the number of classes remains constant thus not relieving any of the teachers.

11. Wastage may occasion a minor reduction in building costs but this is not likely to be quantitatively significant.

Failure to adjust the total social cost for the reduction occasioned by wastage thus may represent a slight overestimate of the costs of education.

TABLE 5.4.1.

The Educational Product Mix

(1)	Title of output (2)	Years of course completed (3)	Percent of total intake expected to complete the course with the qualifications listed in column 2, and to find employment (4)
Uneducated[b]			91
Primary School	Leaver		65.0 (58.5)[c]
	Dropout		14.5 (13.[illegible])[c]
Craft School	Leaver		4
	Dropout		
Grade III Teacher Training	Pass	4	59.9
	Fail	3	33.7
	Dropout	1, 2	
Secondary Grammar School	Pass	5	48.6
	Fail, Class IV	4, 5	38.6
Grade II Teacher Training	Pass	2	37.3
	Fail, Dropout	1, 2	57.7
Technical Training School	Pass	3	100
Form VI	Pass	7	57.5
	Fail		42.5
Northern Secondary Teachers College	Pass	5	
	Fail, Dropout	1	
University	Graduate	3, 4	
	Dropout	1, 2, 3	

a. Figures in Column 4 are derived from the wastage and failure rates and [illegible] force participation and unemployment rates presented in Appen-

b. In view of the fact that some of the uneducated who attend primary school would not have sought employment on the labor market had they remained outside the educational system, the lifetime earnings stream foregone by the decision to transform an uneducated person into a primary school leaver must be adjusted downwards. This figure of 91% represents the labor force participation rate for the uneducated (aged 15 and above) and is based on the assumption that all males and 70% of the females participate in the labor force. This figure may be somewhat too high and may therefore understate the benefits stream associated with primary education. As the earnings stream of this group must be compared with that of those attending primary school, the sex composition of the uneducated is made roughly equivalent, namely 30% are females.

c. Figures in brackets are adjusted for unemployment.

APPENDIX 5.1

Estimation of the Production Functions

The a_{ij}'s during the student flows are either unity or zero, reflecting the structure of the educational system.

There a_{ij} where $i \neq j$ are output coefficients and carry a negative sign in the equations for the year or years following the last year of the course. Every student input successfully passes the terminal year has an a_{ij} of efficiency. Where wastage and/or failures occur the a_{ij} must be reduced downwards and if necessary the wastages and failures incurred for the output coefficients. The constraint that the education system does not employ more than one third of any years university output is reflected in the setting of the university output coefficients at one third.

The a_{ij}'s are the amount of teachers of qualification i in activity j are

---

13. For example, input to the grade II teacher training course in time period t there is a gross output of .82 in time $t+2$ plus an output of .42 failures and dropouts who are assumed to revert to their highest previous qualification, namely grade III. The coefficients do not add up to one as some of the female inputs will not join the labor force. Failures at the Northern Secondary Teachers College are counted as grade V output.

14. Given present and likely future salary structures and prestige factors, it is unlikely that the education system can absorb even as many as one third of the university outputs.

15. The main sources for the teacher input coefficients are the various publications of educational statistics which appear in the bibliography.

A5.1.1 $a_{ij} = T_{ij}/\overline{X}_j$

where T_{ij} is the total number of teachers of qualification i teaching in level j;

$\overline{X}_j$ is the total number of students enrolled in level j.

Two methods were used to estimate the future values of the a_{ij}'s (t=1 is the year 1965...1971). Some are estimated on the basis of equation A5.1.2a or A5.1.2b below and the historical data which appear in Table A5.1.1. The estimated parameters of equations A5.1.2a and A5.1.2b.

A5.1.2a $a_{ij} = \alpha + \beta t + \gamma t^2$

A5.1.2b $a_{ij} = \alpha \beta^t$

appear in Table A5.1.1.b

In the case of a number of input coefficients no statistically significant time trend was discernable and the overall estimating equation yielded an R^2 that was insignificantly different from zero at the 95% level of significance. For these coefficients the values observed in 1964 have been retained over the entire planning period.

In cases where a clearly indicated discontinuity in the past and planned future movements of the input coefficients made the use of historical data inappropriate, or where more specific data on the likely movement of the a_{ij}'s over the planning period were available, the time

---

A5.1.1. The method used is similar to that developed by K.S. Arrow and M. Hoffenberg in A Time Series Analysis of Inter-Industry Demands (Amsterdam: North-Holland Publishing Co., 1959). In estimating the a_{ij}'s, I have associated t=1 with the year 1957. Throughout the rest of the essay, t=1 and p=1 refer to 1964.

TABLE A5.1.1a

Historical Data on Teacher Input Coefficients (a_{ij}'s)

		Category of Teacher:			
Primary School Inputs For Years:		Grade III	Grade II	NCE[a]	Graduates
	1957	.00839	.00388	.00041[b]	
	1958	.00929	.00336	.00044[b]	
	1959	.01020	.00423	.00043[b]	
	1960	.01195	.00446	.00040[b]	
	1961	.01211	.00453	.00030[c]	
	1962	.01395	.00449	.00026[c]	
	1963	.01263	.00506	.00020[c]	
	1964	.01257	.00546	.00021[c]	
Craft School Inputs For Years:					
	1962	.00361	.01688	.02050	
	1963	.00223	.01515	.01790	
	1964	.00104	.01771	.01563	
Teacher Training College Inputs for Years:					
	1957	.00354	.01413	.03452[b]	.03298
	1958	.00262	.02001	.04067[b]	.02952
	1959	.00276	.02427	.04610[b]	.03103
	1960	--	.01969	.01969[b]	.01386
	1961	--	.01820	.02527[c]	.02099
	1962	--	.01550	.01946[c]	.02405
	1963	.00142	.01080	.01891[c]	.02380
	1964	--	.00941	.01827[c]	.02093
Secondary Grammar School Inputs for Years:					
	1957	.00109	.01506	.02437[b]	.03313
	1958	--	.01297	.02031[b]	.03524
	1959	--	.01024	.01665[b]	.03480
	1960	--	.00510	.02235[b]	.03287
	1961	--	.00570	.02173[c]	.03376
	1962	.00050	.00725	.00750[c]	.04275
	1963	.00091	.00495	.00789[c]	.03947
	1964	.00067	.00598	.00657[c]	.03120

a. NCE (Nigerian Certificate of Education) includes those holding the Ministry of Education Certificate, the University of London Institute of Education Diploma and Grade I teachers, as well as NCE holders.

b. including Grade I

c. excluding Grade I

Source: Annual publications of educational statistics, 1957-1964 as presented in the bibliography.

TABLE A5.1.1.b

Estimating Equations for the Temporal Movement of the Teacher Input Coefficients

A. Estimates Relying on Time Series Analysis: [a,b]

	Intercept 1	Coefficient of Time[c] 2	Coefficient of Time^2 3	R^2 4	D 5
Inputs into Primary Schools [d]					
Grade II Teachers	.00357 **	.00010	.0000	.850 **	1.454 *
Inputs into Craft Schools					
Grade III Teachers	.01128 *	-.00128 *		.998 *	3.0
Inputs into Teacher Training Colleges					
Grade II Teachers	.01213 *	.00479 *	-.00067 *	.824 *	.902 *
Grade III Teachers	.00338 **	-.00046 *		.508 *	1.631 *
Inputs into Secondary Grammar Schools					
Grade II Teachers	.01440 **	-.00133 **		.706 **	1.141 u

B. Estimates Based on Government Plans

N.C.E. Teachers in Primary Schools (1)
Craft Schools (2)
Teacher Training Colleges (3) & (5)
Secondary Grammar Schools (4)

$$a^t_{8i} = a^8_{8i} e^{r_i(t-8)}$$

Where a^t_{9i} = the minimum amount of NCE teachers required to accommodate one student at activity i in time t, t = 9....15 (i.e. 1965....1971) and i = 1, 2, 3, 4, 5

a^8_{8i} = the observed value of the a_{8i} coefficient in 1964

r_i = the rate of change of the a_{8i} coefficient implicit in government plans e

r_{8i} = .110?

r_i = .0397 for i = 2, 3, 4, 5

Notes for Table A5.1.1

a. Regression equations for each set of data were computed using time alone and using time and time squared. In choosing the best predicting equation only those with a significant F ratio which on the basis of present government policies and capabilities appeared plausible were considered. Among these equations with the highest R^2 was chosen.

b. An asterisk (*) appearing in columns 1....4 indicates that the statistic is significantly different from zero at the 95% level of significance. A double asterisk indicates a 90% level of significance. The relevant Durbin-Watson statistics appear in column 5. R indicates that the null hypothesis of random disturbance must be rejected at the 95% level of significance in favor of serial correlation of the or terms. U indicates that the Durbin-Watson test has been inconclusive, and * indicates that the null hypothesis should not be rejected.

c. Time was set equal to 1....8 for the years 1957....1964 respectively.

d. The grade III teacher input coefficient has been set so as to maintain a gradual increase (.00025 annually) in the ratio of total trained teachers (NCE, II's and III's) to students. The values of the coefficients thus reflect the present government's intention to reduce the fraction of the primary school teaching force composed of untrained teachers.

e. Because the government was already considerably behind their planned targets by 1964 the actual 1964 figures (rather than the planned) were used with the rates of growth of the coefficients implied in the Archer Report.

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Federal Office of Statistics a 30-year length of life for school buildings and equipment was used.

In attributing the costs of teacher training to the planning period it was assumed that the average working life of a teacher was 30 years. The values of F, computed on the basis of equation 5.2.1 appear in Table A5.1.2.

adjusted to account for expenditures which would have been incurred even in the absence of education.

costs of all goods and services ordinarily provided for students in the school concerned i.e. the costs of providing them in households, occupational systems etc. Those elements of cost which cannot be directly attributed to education are deducted from the total. The figure for costs per student per year, borne by educational institutions, but not including the social costs, was £55.5 for the post-primary institutions and £200 for higher education.[20]

19. The source for these calculations was the Federal Office of Statistics Urban Consumer Surveys in which reports on families into the income and expenditure patterns of wage earner households in Lagos and other urban areas were collected. The budget figures were (Lagos: Federal Government Statistics, 1965). The occupational groups selected from the income and occupational group most closely corresponding to the students likely post-school incomes were then corrected for price changes since the school system. The 1956 figures used were corrected for price changes since that period, using the Consumer Price Index Numbers as presented in Federal Office of Statistics, Digest of Statistics, (Lagos: by the author, July, 1964), Vol. 13.

20. Use of this figure for higher education may result in a slight over-estimate of the social costs of higher education. The calculation for the Northern Secondary Teachers College and the Sixth Forms were performed on a slightly different computational basis.

TABLE AS.1.2

Values of P

(The fraction of teacher training costs allocated to the planning period)

Alternative Methods were

	n = 5	10	15	20	25	30	35	40
Grade I: [illegible] equations AS.1.2a								
[illegible] numbers in Table AS.1	$r = .10$	.07	.05	0	0	0	0	0
	$r = .05$	.28	.23	.17	.12	.06	0	0
	$r = .10$	.41	.34	.27	.19	.10	0	0
Grade II [illegible]								
	$r = .10$ [illegible]	.20	.16	.13	.10	.07	.03	0
	$r = .05$ [illegible]	.33	.28	.21	.17	.12	.06	0
	$r = .10$ [illegible]	.47	.41	.34	.27	.19	.10	0

a. Cf. The discussion in section 5.2 and especially equation 5.2.1.

b. No change in levels of productivities which produce their output after the terminal year.

[illegible] retained over [illegible]

In cases [illegible]

planned future [illegible]

[illegible]

cost of [illegible]

[illegible]

[illegible]

The cost inputs for the universities have been estimated on the basis of their projected budgets and enrollments.[21] The total social cost input coefficients for university study, $a_{10,9}$, were computed by:

$$a_{10,9} = \frac{\Delta X}{\Delta Y}$$

where: ΔX = the change over the period 1963-8 in student enrollments (capacity) projected by the universities

ΔY = the projected change in total annual costs including a depreciation charge on the increase in buildings and equipment

The use of the marginal rather than average costs at the university level is appropriate. Expansion of university enrollments over the planning period will take the form of additions to the student body of already established institutions (Ahmadu Bello University).[22] Present average per student costs are extraordinarily high, largely because of the small scale of production. The low marginal costs can be attributed largely to the fact that the early 1960's Nigerian universities built ahead of demand, and now exhibit low utilization rates for most types of facilities. Thus a substantial increase in the number of students could be accommodated with only minor additions to plant and equip-

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21. The major sources here were the National Universities Commission, Report (Lagos: Federal Ministry of Information, 1963) and, "Annual Review of Nigerian Universities--1963/4" (Lagos)(Mimeographed,), and various data from the National Universities Commission financial files.

22. The total enrollment in Ahmadu Bello University in 1964 was 558. (Federation of Nigeria, Federal Office of Statistics, Annual Abstract of Statistics, 1964 (Lagos: Federal Government Statistician, 1964), p. 164).

ment.[23] In all other activities the average cost figures are appropriate as expansion of enrollments will take the form of additions of new production units of approximately the present average scale.[24] Because the vast majority of Northern university students will over the next few years attend Ahmadu Bello University in Zaria, I have used the cost figures for that university. Use of a national average would not significantly affect the results.

The university costs are estimated on the basis of the figures for recurrent costs from Ahmadu Bello University alone, and for capital costs from the entire federation with a number of corrections to make the national figures applicable to conditions at Ahmadu Bello University.

The cost to Nigerians of university study abroad has been based on costs in the U.S. and the U.K. (the major hosts to Nigerian students),[25] and an average of the two figures used.[26]

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23. The very high teacher student ratio at Ahmadu Bello University could probably be reduced as total enrollment increases. However, university officials have expressed their intention to maintain the ratio at its present level. Cf. National Universities Commission, Report, p.39.

24. The policy of proliferation of schools is being followed even in higher teacher training, where the decision has been made to add a second institution (The Kano Day Teacher Training College) rather than concentrate expansion of higher teacher training in the Northern Secondary Teachers College.

25. Ministry of Education, National Students Registry (Lagos: Government Printer, 1965).

26. For the U.S. the information was obtained from a sample of universities in Clarence Lovejoy, Lovejoy's College Guide (New York: Simon and Schuster, 1961). For the U.K. data was supplied by the British Council, Lagos, the organization which sponsors Nigerian students in the U.K.

The annual costs of importing foreign teachers (activities X_{10} and X_{11}) is the transportation cost plus the additional costs attributable to the teachers being foreign (expatriate allowance) and the alternative rental value of the housing which they occupy. The costs of using these teachers is allocated to the using activity.[27]

27. The expatriate allowance appropriate to X_{10} is £240 per annum; for X_{11} the figure is £180. The rental value of housing provided is estimated at £1200 per annum, and the total air fares at £375 per annum for both activities.

APPENDIX 5.2

The Stability of the Input Coefficients

The degree of confidence which one can place on the use of the mean teacher student and cost per student coefficients depends to large degree on the distribution of the individual observations around the mean. Clearly if all observations are widely distributed around the mean less confidence can be placed in the results than if the distribution is compact, i.e. low standard deviation. The standard deviation of the [illegible] observations is a measure of the homogeneity of these technical coefficients of production and of the [illegible] underlying production process.

Ideally we would be able to estimate the cross sectional [illegible] of observations underlying each parameter. In the absence of the necessary school by school cross-sectional data no comprehensive appraisal was made to extend analysis in this direction.

However, observations were available for recurrent cost per student for primary schools in sixty-one local government areas and for recurrent non-boarding costs for all government secondary schools.

The mean of the primary student expenditure figures was £8.78, and the standard deviation was £1.97 or 24 percent of the mean. Analogous figures for secondary schools were 117.9, 6.8, and 5.[illegible] percent respectively.[28]

---

28. These figures apply to 1963 and are not strictly comparable to those presented in Table 5.1. The relatively larger standard deviation of the primary school figures is to be expected given the less rigorous inspection and auditing at the primary school system and the greater possibility of errors in observation at the primary school level.

The sensitivity of the model to an error in these parameters of one standard deviation will be tested in Appendix 7.1.

Appendix 5.3

[illegible] ducational [illegible]uct Mix

The basic da[illegible]erlying Table [illegible] 4.1 is presented in Tables [illegible] 3.2.

[illegible] required to es[illegible]imate the educational pro[illegible]
duct [illegible] [illegible] labor fo[illegible]e [illegible]articipation and unemployment
[illegible] [illegible] [illegible] activity. [illegible]justment for labor force
[illegible] [illegible] [illegible]me on the assu[illegible]ion that 30 percent of the
fema[illegible] [illegible] [illegible]0 percent [illegible] the females in grades 13 and
III [illegible] [illegible] [illegible]leges, and 50 percent of those in secondary
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[illegible] [illegible] [illegible] in the labor force produce no benefits. It
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[illegible] [illegible] [illegible]ball, and there is [illegible]son to believe that most of them
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[illegible] [illegible] [illegible] rate of 10 percent. This estimate is based on the available

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29. In view of the evidence that the father's level of education is closely associated in the children with a number of personality characteristics thought to be conducive to economic growth, the decision to ascribe all benefits to the education of women who stay at home may understate the benefits of education. Cf. David C. McClelland, The Achieving Society (Princeton: D.VanNostrand, 1961), pp. 46-50 and T.W. Schultz, "Education and Economic Growth," Social Forces Influencing American Education, Nelson B.Henry (ed.) (Chicago: University of Chicago Press, 1961), pp. 46-85.

APPENDIX 5.3

[illegible] the Educational Product Mix

The basic data underlying Table 4.1 is presented in Tables [illegible]

3.2.

required to estimate the educational pro-

duct mix concern the [illegible] labor force participation and unemployment

[illegible] activity. Adjustment for labor force

participation rates [illegible] on the assumption that 30 percent of the

female [illegible] 70 percent of the females in grades 13 and

III [illegible] primarily devoted to

[illegible] ages, and 50 percent of those in secondary

[illegible] the labor force. In the framework of the

[illegible] in the labor force produce no benefits. It

[illegible] were subtracted from the

[illegible] will join the labor force. No adjustment is

[illegible] condary school courses as the number of women students

[illegible] ball, and there is [illegible] son to believe that most of them

[illegible] or force.

only adjustment for unemployment was at the primary level

[illegible] rate of 10 percent. This estimate is based on the available

[illegible] The Hodger figures

29. In view of the evidence that the mother's level of education is closely associated in the children with a number of personality characteristics thought to be conducive to economic growth, the failure to ascribe substantial benefits to the eduction of women who stay at home may underestate the benefits of education. Cf. David C. McClelland, The Achieving Society (Princeton: D.VanNostrand, 1961), pp. 46-50 and T.W. Schultz, "Education and Economic Growth," Social Forces Influencing American Education, Nelson B. Henry (ed. (Chicago: University of Chicago Press, 1961), pp. 46-85.

TABLE A5.3.1

Wastage and Pass Rates Underlying Table 5.4.1

	Percent of students in year n of the course indicated expected to pass on to year n plus 1 (P_n)						Pass Rate[b]
Primary[c]							
Male	96.3	96.1	97.2	(97.5)	97.9	98.9	*
Female	92.8	91.9	95.5	(91.6)	89.9	93.9	*
Grade III and B.C.C.							
Grade Schools	96	93					
Grade III Teacher Training College[d]		80					
Male	96.0	96.0					
Female	95.6	98.8					
Secondary Grammar School							57.6
Male	99.5	98.2	97.8	100.0			
Female	96.5	100.0	95.5	91.0			
Grade II Teacher Training College[e]							
Male	96.0						
Female	95.6						
Technical Training Schools[f]	100.0	100.0					*
Form VI[g]	100.0						57.5
Northern Secondary Teachers College[h]	92	92					60
University[i]	78.9	78.9	78.9				78.9

a. The survival rates (P_n) are defined as the percentage of the students in year n which is expected to proceed to year n plus one. They are estimated on the basis of enrollments by year of course in each activity for 1963 and 1964. Thus:

$$p_n = \frac{N_{n+1,t+1}}{N_{n,t}} \cdot 100$$

where $N_{n,t}$ is the number of students in year (class) n in time t, and $N_{n+1,t+1}$ is interpreted analogously. This method of computing survival rates is clearly inappropriate where retardation or transfers out of the system are significant. Information given by the senior inspector in charge of each activity revealed that retardation and transfers out of the system (i.e. out of the Northern Region) are virtually non-existent.

b. Pass rates are in percents and are based on 1963 data. An asterisk (*) indicates either that no leaving certificate is given, or that its award is virtually automatic.

c. Because of the present structural break in the primary school system between years 4 and 5 (the passage from "junior primary school" to "senior primary school") there is a large dropout at this point. Ideally all students who entered school during the plan period should have the opportunity to pass through the entire system (i.e. all junior primary schools are being up-graded to full primary schools). Consequently it was decided to substitute the annual average survival rate for the observed rates for the passage from year 4 to 5.

d. Where no male/female breakdown is given, the activity is either all male (craft schools and the technical training schools), or there is no appreciable difference between the sexes with respect to the relevant data.

e. Because of the disruption in the Teacher Training College courses in 1963/4 due to a number of policy changes, the wastage rates were estimated on the basis of 1962/3 data, and the 1963/4 data which were available.

f. Because of the changes in the structure of some courses in the technical training schools in 1963/4, data for 1962/3 were used to estimate the product mix of this activity.

g. A pass on the Higher School Certificate examination was defined as two or more subjects passed; this is the usual requirement for university entrance.

h. The pass rate and the dropout rate for years 2 to 3 in the Northern Secondary Teachers College was estimated on the basis of exam results at a similar level (Form VI) and the dropout rates observed between years 1 and 2. Data on the first passage of students from year 2 to 3 (Jan. 1965) is not yet available.

i. Estimates for wastage at the university level were based on a survival rate over the entire course. Hence no year by year breakdown is given. No distinction between university failures and passes is made as the relevant estimates of earnings are not defined for pass

$$P_n = \frac{N_{n+1,t+1}}{N_{n,t}} \cdot 100$$

where $N_{n,t}$ is the number of students in year (class) n in time t, and $N_{n+1,t+1}$ is interpreted analogously. This method of computing survival rates is clearly inappropriate where retardation or transfers out of the system are significant. Information given by the senior inspector in charge of each activity revealed that retardation and transfers out of the system (i.e. out of the Northern Region) are virtually non-existent.

b. Pass rates are in percents and are based on 1963 data. An asterisk (*) indicates either that no leaving certificate is given, or that its award is virtually automatic.

c. Because of the present structural break in the primary school system between years 4 and 5 (the passage from "junior primary school" to "senior primary school") there is a large dropout at this point. Virtually all students who entered school during the plan period should have the opportunity to pass through the entire system (i.e. all junior primary schools are being up-graded to full primary schools). Consequently it was decided to substitute the annual average survival rate for the observed rates for the passage from year 4 to 5.

d. Where no male/female breakdown is given, the activity is either all male (craft schools and the technical training schools), or there is no appreciable difference between the sexes with respect to the relevant data.

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i. Estimates for wastage at the university level were based on a survival rate over the entire course. Hence no year by year breakdown is given. No distinction between university failures and passes is made as t[illegible] estimates of wastage were not defined for pass

TABLE A5.3.2

The Educational Production Matrix: The Basic Data[a]

Activity	Input	Year	1	2	3	4	5	6	7
Primary	100	A	5.6	4.6	3.6	3.7	3.4	2.0	76.9
	100	B	100.0	94.4	89.8	86.0	82.3	78.9	76.9
Male	70.2	A	3.6	2.6	1.6	1.7	1.5	0.7	50.4
Female	29.8	A	2.0	2.2	2.0	2.0	1.9	1.3	26.5
Craft School[b]	100	A	2	2	96				
	100	B	100	98	9				
Grade III Teacher Training College	100	A	4.6	4.3	63.9	(27.5)			
		B	100	95.5	91.2				
Male	20	A	3.2	3.1	51.6	(22.1)			
Female	80	A	1.3	1.2	12.3	(5.2)			
Secondary	100	A	1.3	1.4	2.6	1.7	53.5	(30.6)	
	100	B	100	98.7	97.3	94.7	53		
Male	70.8	A	0.6	0.4	1.7		40.8	(32.3)	
Female	29.2	A	0.7		0.9	1.7	9.7	(7.2)	
Grade II Teacher Training College	100	A	4.5	3.2	50.3				
	100	B	100	95.5					
Male	83.4	A	3.4	22.8	(47.2)				
Female	16.6	A	1.1	6.3	(9.1)				
Technical Training School	100	A	-	-	100				
	100	B	100	100	100				
Form VI	100	A	-	57.5	(42.5)				
		B	100	100					
Northern Secondary Teachers College	100	A	8	7.4	50.0	(33.8)			
		B							
University	100[a]	A	21.1	21.1	78.9				
		B	100	78.9	78.9				

Row A: Expected output after year n, (O_n)

Row B: Expected number of students remaining in the system in year n, (N_n)
Failures after the terminal year shown in parentheses

a. The data in this table is based directly on the data in Table A5.3.1. The expected number of students in school in the nth year of their course, N_n is estimated as:

$$N_n = 100\ (P_1) \ldots (P_n)$$

where P_n is the estimate of the percentage of those in year n expected to pass into year n plus one (this is referred to as the "survival rate"). This is estimated

$$\delta_n = N_{n-1} - N_n$$

b. The male/female breakdown of each type of education was estimated from the sources listed below Table A5.3.2.

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with the principal contributor, Dr. Archibald Callaway.

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Nigeria and the likely rapid growth in demand

and jobs for

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30. Archibald Callaway, "School Leavers and the Developing Economy of Nigeria," Conference Proceedings, October, 1960 (Ibadan: Nigerian Institute of Social and Economic Research, 1960), pp.1-16, and "Unemployment Among African School Leavers," The Journal of Modern African Studies, Vol.I, No.3 (1963), pp. 351-371.

31. The importance of [illegible] was addressed most ably by Dr. Archibald Callaway.

adoption (see section 6.1) the unemployment estimate may be [illegible]

Although the estimates concerning unemployment and labor force participation rates are consistent with the available quantitative information and [illegible] experience, they have not been [illegible] illustrative.

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82. Unemployment of primary school leavers in the three southern regions of Nigeria appears to be a much more serious problem. This fact and a number of other peculiarities of Northern Nigeria suggest that the applicability of the results of this model to other regions in Nigeria may be limited.

83. It is worth pointing out, however, that the results of the model appear to be insensitive to a wide margin of error in these estimates (cf. Appendix [illegible]).

Chapter 6: THE DEMAND FOR [illegible]

This chapter presents estimates of [illegible] wages of the products of the various educational [illegible] these and other data the coefficients of the [illegible] planning [illegible] are estimated.

Section 6.1 introduces some data on the existing educated labor in the economy. Estimates of the growth [illegible] are presented in section 6.2. Some problems concerning the [illegible] appropriate data are discussed in section 6.3. The [illegible] earnings and of the net present value of the output [illegible] course are presented in section 6.4.

6.1 The Present Stock of Educated Labor.

While the supply and demand [illegible] educated labor levels cannot be observed, we [illegible] idea of present imbalances by an [illegible] labor in each educational category. There [illegible] information on this aspect of the labor force.

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1. The figures in Table 6.1.1 represent [illegible] employing ten or more persons. Total [illegible] in Nigeria in 1960 was 650,000, or probably [illegible] percent [illegible]. Cf. Federal Office of Statistics, [illegible] and Vacancies in Nigeria, 1960 (Lagos: the Chief Statistician, [illegible] while the larger firms undoubtedly account for a higher [illegible] of educated labor, the figures presented in Table 6.1.1 are [illegible] derably underestimated. The National Manpower Board has adjusted figures upward by 10 percent to account for the exclusion of [illegible] ablishments (T. [illegible] Preparing Nigeria's Manpower [illegible] presented to the [illegible] opment with Special Refer[illegible] Nigeria, Lagos, March 2-[illegible] (Mimeographed.)

Employment of [illegible] various Categories, 1[illegible]

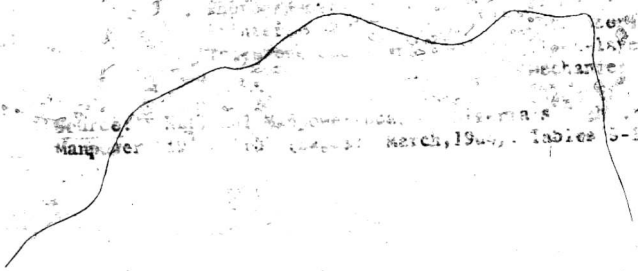
(Including Teaching and Research Staff)

	NORTH	TOTAL ALL REGIONS
I. Senior Category[a] (Total for the Category)	2,099	12,[illegible]
A. Arts and Social Studies (total)	1,525	9,[illegible]
Nigerians		
Public[c]	482	4,204
Private	286	2,187
Total	768	6,391
Expatriates[d]		
Public	[illegible]	812
Private	[illegible]	2,186
Total	[illegible]	3,398
B. Sciences (total)	574	2,664
Nigerians		
Public	[illegible]	[illegible]
Private	[illegible]	[illegible]
Total	123	1,262
Expatriates		
Public	281	611
Private	170	811
Total	451	422
II. Intermediate Category[e] (Total for the Category)	16,357	32,682
A. Arts and Social Studies (total)	5,394	16,313
Nigerians		
Public	5,316	10,717
Private	76	4,848

Table VI. 1. (cont.)

Total			
Expatriates			
Public		87	
Private		95	
Total		182	
B. Sciences	(total)	3,943	
Nigerians			
Public		3,286	
Private		388	
Total		[illegible]	
Expatriates			
Public		69	
Private		206	
Total			
III. Other degrees (total for Nigeria)		5,638	0.
A. (Arts and Social Sciences)			
Nigerians			
Public		3,196	
Private		1,041	
Total			
Expatriates			
Public		2	
Private		45	
Total		47	205
B. Sciences	(total)	1,370	12,151
Nigerians			
Public			

a. Employment [illegible] with ten or more employees.



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...northe... Nigeria

...exclude any further significant demand ... itself, and are based on ...ock figures which may represent co...siderable underestimates.

4. See the bibliography.

5. The decision to sample only from the private sector was made on the grounds that institut...nal and other non-productivity considerations are less important in determining the level of wages in private than in government-owned establishments. A description of the sample design is presented in Appendix 6.2

TABLE 6.2.1.

Estimated Growth in Demand for Educated Labor[a]

	Estimated Shift in the Demand Curve per Annum	Estimated Shift in Demand Curve Corrected for Retirements.[b]	Estimated Stock in 1963[c]	Estimated Demand at Existing Wages for New Entrants into the 1964 Labor Force.
(1)	(2)	(3)	(4)	(5)
Primary School Leavers	7.84	10.84	287,700	31,186
Technical Training School Leavers	7.37	10.37	5,844	606
Secondary School Leavers	7.65	10.65	11,726	1,249
University Graduates	8.68	11.68	2,300	269

a. Note the warning concerning the theoretical and empirical weaknesses of these estimates in footnotes 1 and 2, and Appendix 6.1. These estimates exclude the demand by the educational system itself for both continuing students and teachers.

b. The correction for retirement is based on the National Manpower board's estimate that the retirement rate from the labor force is 3 percent per annum. It is assumed that the number of foreigners and Nigerians not indigenous to the Northern Region employed in the North will remain constant. In view of the present "Northernization" policy (the replacement of non-Northern by Northern-born labor) the figures may represent an underestimate of the rightward shifts in demand.

c. The stock figures (except row 1) follow the National Manpower Board in adding 10 percent to the figures in Table 6.1.1 to allow for undercounting. See T.M. Yesufu, "Forecasting Nigeria's Manpower".

d. The present stock of primary school educated labor is estimated on the basis of primary school enrollment figures for the years 1952 to 1963, estimates of enrollments for the years 1941 to 1951, and estimated wastage rates. Inclusion of estimates for the pre-1941 years would not significantly affect the results. While there are a number of weaknesses in this procedure, an alternative method based on total labor force estimates and assumed primary sch[illegible] estimate virtually iden[illegible]

At the university level there is considerable inter-regional mobility of labor and no evidence of significant inter-regional earnings differentials; for this reason observation on the earnings of university graduates were taken from the entire federation.

The choice of data for the estimation of the expected future time profile of earnings presented a number of [illegible] of a number of writers in this field has relied on [illegible] population classified by age, education attained and [illegible] technique is inapplicable where the age structure of most [illegible] more than a few years education is very yo[illegible]

243

structure of a se[illegible]ssio[illegible]

resented [illegible] Table 6.3.1.

TABLE 6.3.1

Age Structure of Selected Occ[illegible]

Age Group	[illegible] 25	26-30	31-35	36-40	41-45	46-50	>50
Percent in Age Group	2.2	24.1	37.8	23.1	7.9	4.0	.9

Source: Federation of Nigeria, National Manpower Board, A Study of Nigeria's Professional Manpower [illegible] Occupations (Lagos: Government Printer, 1964), Table 6.

Many of those above 30 are earning very large salaries in positions

6. See Herman Miller, "Income and Education...", Gary Becker, Human

which were Nigerianized in the 1950's and early 1960's, a period in which educated Nigerians were in great demand to fill government posts previously held by expatriates. The present student body cannot expect such rapid advancement and for this reason current cross-section was thought to be likely to exaggerate the increment in productivity attributable to present education.

The raw data for the estimates of the time profile of earnings are existing salary scales. The governments of Nigeria and the major private firms have well-established starting salaries for most jobs as well as a fixed pattern of yearly increments which differ from occupation to occupation. It was thought that these scales are a reasonably good reflection of employers' estimates of the relation between work experience and productivity in the various occupations.[7] One important weakness of the estimation procedure should be pointed out. Most of the salary scales used specify the relation between earnings and years of experience for a period of considerably less than 15 years. Beyond the period specified in the salary scales a worker may be promoted to a different, higher scale, remain at the final position in the scale, or a number of other alternatives. Moreover, the question of job shifing (movement from one scale to another)

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[7] files for the lower ... off than do the ... which [illegible]

may be important at any point in the salary scale.[8] The lack of data on promotions or transfers to other salary scales has necessitated a somewhat arbitrary treatment of the shape of the time profile of earnings after the initial years.[9]

Earnings Accruing to Educated Labor.

The observations on wage and salary scales from the sample of the private sector were used to estimate the time profile of earnings accruing to the output of each activity.[10] The earnings observations were regressed on [illegible] to arrive at an estimate of the earnings accruing to the [illegible] activity in each year of his working life.[11] The [illegible] time earnings and the per student social costs form the [illegible] the objective function. Both the costs and the earnings stream [illegible] at the social time discount rate.[12] The objective function [illegible] for activity X_j^p is: $Z_j^p = Y_j^p - P_{\_} - C_j^p$

[illegible] the [illegible] job shifting takes place between jobs at the [illegible] in terms of earnings and [illegible] attainments) no[illegible]

[illegible] and the [illegible] earnings [illegible]

[illegible]

Where: Z^P_j = the objective function coefficient for activity X^P_j;

Y^P_j = the present value (discounted to year 1) of the earnings accruing to an output of activity X^P_j;

Y^P_{jn} = the present value (discounted to year 1) of the earnings stream, beyond that which would have accrued to the individual had he not received education at activity j;

C^P_j = the present value (discounted to year 1) of the per student cost operating activity X^P_j for the entire course of study.

Estimates of Z^P_j, Y^P_j, C^P_j appear in Table 6.4.1.[14]

Before passing on to the [illegible] of the assumptions underlying the [illegible] it should be remarked that most of the jobs listed under Intermediate category are those with a West African School Certificate. First, the use of [illegible] as a basis for the estimation of the contribution to future national income relies on the assumption that workers are paid according to their marginal net product. Secondly, the use of present earnings as a basis for the estimation of future earnings relies on the assumption that the [illegible] absolute differences in earnings accruing to labor educated to different levels and with a given number of years experience will remain constant over time.[15]

[illegible] figures on earnings [illegible] are adjusted for the labor force participation and unemployment rates and for failures and drop-outs using the data presented in [illegible] 6.4.1.

It should be emphasized that the terms [illegible] are defined in Chapter 2 in terms of streams of future social marginal productivity; in Table 6.4.1 they are represented on the basis of future earnings, which is at best a reflection of private marginal productivity.

15. It should be pointed out that given general increases in output per worker, constancy of the absolute differences in earnings is consistent with a narrowing of the relative [illegible]. For a discussion of this [illegible] see [illegible] 6.

TABLE 6.4.1

The Present Value of the Net Benefits Associated with Each Educational Activity in Year One.[a] (in £'s)

	Activity	Present Value of Lifetime Income[b] (2)	Present Value of Income before (3)	Net Increment in Present Value (4)	Present Value of Social Costs (5)	Present Value of Benefits (6)
1	Primary School	1659	611	1048	62	986
2	Craft School		197		300	-497
3	Grade III Teacher Training College[d]		60		85	-145
4	Secondary School	4592	2910	1382	476	906
5	Grade II Teacher Training College[d]		90		68	-158
6	Technical Training	4477	2713	1626	787	839
7	Form VI	7460	7356	104	326	-222
8	Northern Secondary Teacher's College		210		137	-347
9	University Study	20559	9130	11429	1350	10079
9a	University Abroad	20559	9130	11429	1730	9699
10	Import University Graduate Teacher[e]				835	-835
11	Import Well-Qualified non-Graduate[e]				755	-755

...ering indicate the ri... wards move... t of the demand curve for ...ed labor, namely, the increase over ti... the amount of ...demanded at the present wages, all ot... and va... s ...ining unchanged. The ... about with the assignment for ...rameters are presented in Table 6.2.1.

It is significant ... types of labor ... l the e...mated ... into the ... eded tr... p+s ... ystem by ... able ...im.[3] Th... ...1+i)^{-t+1} ... economic growth in ...gth has ... more ... ...ture of ...tion- ...utput at present leve...

The ... of ...opriate ... ...iput ... activity X_j^p in time t;

y_{jt}^p = expected earn... ...earnings accruing ...considerable ...

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...ber of different educ... ...skill levels.

y'_{jt} = expected earnings in ... me t of an ...ividual possessing the prerequisites for en... into X_j^p bu... who enters the labor force in time p.

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c_{jt} = per student cost of operation ... X_j in time t; $c_{jt}=0$ for $t<p$

...s that the en... ...fits ... $t \geq p+s_j$

...ssion ... the ...

l_j = expected length of working life after graduation from j

l'_j = expec... length of working life after o... ining the prerequisites for entry into j ... the ...stitutional

s_j = length of course j ... years

...t. rate of social time ...

a. The objective function coefficients for p = t where t=1 are equal to the figure in column 6 multiplied by $\frac{1}{(1+i)^t}$ when i is the rate of social time discount.

b. Present value of expected lifetime income is adjusted for dropouts, failures and labor force participation and unemployment, based on figures in Table 5.4.1.

c. The present value of income foregone is the discounted lifetime earnings of an individual who enters the labor force with the prerequisites for admission to level j. Thus the alternative earnings stream for Form VI is the stream accruing to those who had passed the West African School Certificate, not the composite secondary school stream adjusted for failures, dropouts, etc.

d. It will be recalled that the cost attributed to training teachers is a fraction of the total annual costs. The foregone earnings cost is for the years in which the student is enrolled only.

e. The figures in column 5 are annual social earnings. Cf. Appendix 5.1.

[illegible] attendance ratios gave [illegible]
[illegible] that used in this table

Third, it is assumed that the observed income differentials can be attributed entirely to differences in education. This is clearly not the case if intellectual and physical aptitudes, parental wealth or various socio-psychological attributes which are positively correlated with an individual's future marginal productivity are also positively correlated with his likelihood of getting an education.[16] The model is operated on an alternative assumption in Appendix 7.1.

Fourth, even if the first three assumptions were close approximations of reality, it should be pointed out that the observed earnings measure the private marginal productivity to the individual or the firm rather than his social marginal productivity. The external benefits generated by an educated individual may be considerable,[17] to the extent that they exist the private marginal productivity figures used here are an underestimate of the social marginal productivity.[18]

Fifth, the use of a linear objective function implies that as the percentage of each age cohort admitted to school changes there is no appreciable change in the ability of the student intake. The discussion of this problem in Appendix 6.4 suggests that even in the presence of

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16. The author has impressionistic grounds for believing that the likelihood of a child's getting an education in the Philippines is correlated with a number of personal characteristics

large increases in enrollments in recent years in the education process will affect an improvement in the quality of the student intake of most educational institutions over the next ten years.

Sixth, the objective function measures only those effects of education which result in higher earnings. The benefits which have been defined in chapter 2 as non-economic, namely those which affect the non-income terms in the social welfare function, are not included in the objective function.[19] Thus, the demand for education discussed in this chapter is the demand by producers for a factor of production; the demand for education as a consumers good has been omitted. Since it can be assumed that the net non-economic benefits are positive, the [illegible] of the future streams of net benefits are an underestimate of the net benefits associated with each type of education.

The [illegible] of the estimation procedures, the [illegible] data, and the assumptions underlying the [illegible]ion suggest that the coefficients of the objective [illegible]act to a considerable degree of error.[20]

[illegible] section 2.2 and 2.3.

[illegible] Appendix 7.1

[illegible] human [illegible], p.140.

Appendi... Estimation of the Rate of Growth of Demand ...ab...

figures in Table 6.3.1 are based on the data in Tab... .1,
...chosen are representative of the indic... ...tors
group... ...school educated labor is ...resented ...
...ers and ...as wa... ...thod of
calcul... ...imated ... ...cupation
...which ...age ...ro... rates ... where the
... the ...lative im...ortance of ea... ...ector in the total demand for
...

The ...ed may ...ive ...se... ...onsiderable error in the
..., both t... ...use of ...he shortness and other weaknesses of the na-
...the s... ...he limited coverage and unreliability of ...

...1 ...estima...
...changes ...

TABLE A6.1.1.

Rates of Growth of G.D.P. by Sector and Estimated Rates of Growth for Selected Occupational Groups

	Rate of Growth of Value Added	Percent of Occupational Group i Employed in Sector j				
		Occupational Groups				
	(1)	(2)	(3)	(4)	(5)	(6)
	(1958-1967)	Professional, Technical and Managerial (University)	Clerical (Secondary)	Craftsmen Technical Training School)	Production Process Workers (Primary)	Sales Workers (Primary)
	r_j	q_{1j}	q_{2j}	q_{4j}	q_{5j}	q_{6j}
	(q_{ij})			$j=1,\ldots,8$	$j=1,\ldots,8$	
1. Agriculture	.055			5.4	7.2	
2. Mining			1.0	0.9	6.1	
3. Manufacturing			6.2	12.3	37.2	13.0
4. Construction	.060	1.7	5.8	41.0	28.8	2.0
5. Electricity, Utilities	.191	0.5	1.9	3.8	5.6	
6. Transport, Communication, etc.	.092	1.8	14.2	10.4	2.2	3.0
7. Services	.085	8	44.1	16.4	6.7	14.0

...lue of the Net Benefits Associated with
...tional Activity in Yo **TABLE A6.b.1** (continued)

	Prese... Value of ... gone	Net ... ent of Ea...	Univer-sity (2)	Second-ary (3)	Technical School (4)	Primary (5,6)
Estimated Annual Shi... in the Demand ... Labor of Type i, (2)-(5)			8.68	(5)7.65	7.37	8.34[d]
						5.62[e]
			948			7.84[f]

a. Rates of growth of Gross Domestic Product by sector are computed from data in Federation of Nigeria, Ministry of Economic Development, Federal Government Development Programme, First Progress Report (Lagos: Government Printer, 1964), p.2, based on the national income accounts of the Federal Office of Statistics. Sector 7 (services) in the table is an aggregation of "Government" (Public Administration Defense), "Education", "Health", and "Other Services" in the Federal Office of Statistics Classification. Sector 8 (commerce) is an aggregation of the Federal Office of Statistics sectors, "Banking Insurance and Other Financial Services," and "Distribution".

b. The q_{ij}'s are estimated on the basis of the Federation of Nigeria, Office of Statistics, Report on Employment and Earnings Enquiry, ... (Lagos: The Chief Statistician, 1960), p. 19. It should be noted that while the coverage of the Report is so limited as to make use of its aggregates open to serious question, its figures on the distribution of occupational groups between sectors will be distorted only if the excluded firms are significantly different in this particular respect from those covered in the survey.

c. $R_i = \sum_{j=1}^{8} r_j q_{ij}$

The shift is expressed as a percentage of total employment in occupational group i.

d. Refers to production process workers.

e. Refers to sales workers.

f. Refers [illegible] and [illegible] ... except workers and ...

Appendix 6.2. The Sample of Wages and Salaries in the Private Sector.

The design of the survey was based on the principle of minimizing the standard errors of the important estimates subject to a constraint of time and money.[22] The aim of the sample was to provide enough data for an estimate of the time profile of income for the educational activities used in the model.

The underlying population list for manufacturing and construction (ISIC Numbers 200-499, and 842) was the Industrial Directory, 1964;[23] for establishments in the retailing, wholesaling and financial sectors (ISIC 600-640) telephone directories of the relevant areas in the North were used; and for mining (ISIC 100-199) the underlying population was a list of 122 mining establishments in Plateau Province supplied by the Chief Statistician, Ministry of Economic Planning, Kaduna.[24] Professional services for which earnings are determined largely by conventional charges (e.g. the medical and legal professions) have been excluded from

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22. The wage and salary data required for the objective function would ideally have been based on a more comprehensive survey of the labor force than could be attempted by a researcher without staff and without governmental authority to ensure cooperation. In terms of the sensitivity of the model, the standard errors of the earnings estimates based on the wage and salary data used are not large. Cf. Table A6.3.1, Column 9. However, greater accuracy presently could be achieved through a larger sample. The sample described here should be taken as illustrative of a more comprehensive technique which could be used in any operational situation.

23. Federation of Nigeria, Ministry of Commerce [illegible] 1964 (largest Census discovered for [illegible]

the sample on the ground that these earnings are a poor reflection of marginal productivity.

The overall sampling design for manufacturing was a cluster sample, designed to take advantage of the heavy concentration of manufacturing activity in a few urban centers and the reasonably close geographical proximity of these urban centers. In the absence of population or labor force data it was decided to use [illegible] consumed for industrial and commercial purposes as the criterion of selection; the urban areas which consumed over 4,000,000 kilowatt [illegible] fiscal [illegible] 1963-64 became the primary sampling units.[25]

Within each cluster the availability of data on number of persons employed in each establishment allowed the use of a disproportional stratified random sample. The firms were stratified by the number of persons employed so as to take advantage of the [illegible] cost of obtaining information from large firms and at the same time [illegible] of there being differences in wage structure by [illegible]

25. Kano, Kaduna, Jos, and Zaria, Electricity Corporation of Nigeria, Annual Report, 1963-64 (Yaba, 1964), p. 56.

26. It could not be determined on a priori grounds [illegible] the strata would be relatively homogeneous with respect to the [illegible] to be measured. However [illegible] resulting [illegible] alone provided sufficient [illegible] for its [illegible] (C [illegible] Hurwicz, and W. Madow, Sample [illegible] Wiley & Sons, 1953) Vol. [illegible] [illegible] information [illegible] [illegible]

The sampling proportions chosen were as follows:

number of employees	sampling proportion
10-199	10 per cent
200-499	25 per cent
500 and over	50 per cent

The sample of non-manufacturing establishments was based on a 10 per cent sample of business establishments in the Kaduna telephone directory.[27] The sample of mining enterprises was intended to be restricted to Plateau Province but otherwise identical to that for manufacturing. However, the existence of a single wage and salary agreement for virtually the entire mineefield made this unnecessary.[28]

The information was elicited on the basis of personal interviews with the relevant management personnel preceded by letter of introduction.

The respondent at each establishment was asked to provide a list of job titles for all major jobs in the establishment along with the educational qualifications which a new recruit for the job is expected to have, and the appropriate salary scale.

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27. No establishments engaged in [illegible] were included because most of these have been [illegible] information would have been [illegible] associated [illegible] leaving school [illegible] Appendix 15.

2. and Norton Helmsley, [illegible] pp. [illegible] programme [illegible] was not [illegible]

3. Human Capital, p. 155. [illegible] the observed educational expenditures [illegible] the U.S. can be taken as a [illegible] the maximum estimates almost double the minimum.

TABLE A6.2.1.

Establishments included in the Sample

ISIC Number	Principal Activity	Number in Sample[a]	Number Interviewed[b]
120	Metal Mining	1	1
206	Sugary Products	1	1
209	Cocoa, Chocolate, and Sugar Confectionary	1	1
231	Thread, Yarn, and Woven Textiles	4	4
241	Footwear	1	1
260	Furniture and Joinery	1	1
280	Printed Products	1	1
291	Tanned and Treated Hides and Skins	1	
312	Vegetable and Animal Oils and Fats	3	2
356	Other Metal Products, Except Machinery and Transport, Equipment and Furniture	1	1
383	Motorcycles and Bicycles	1	1
	Construction	5	
		2	2
		1	
		1	
		1	

6. The few establishments which were drawn in the sample but have ceased operations or whose wage policies are administered in detail outside the region have been excluded.

The discrepancy between the number in the sample and the number interviewed is explained by: inability to locate the establishment unwillingness to divulge information (2).

[illegible] repre[illegible] by a weighted

[illegible]tion p[illegible]ess work[illegible] sa[illegible] [illegible]vers. The me[illegible]

[illegible]n produces an est[illegible] rate of growth for occu[illegible]

[illegible]hted avera[illegible] of the [illegible]ral [illegible] of growth

[illegible]

[illegible]s us[illegible]

[illegible]

[illegible] university graduates [illegible]

[illegible] rate of growth of the service [illegible]

APPENDIX 6.3

Estimation of the Time Profiles of Earnings

Table A6.3.1 presents the regression equations underlying the estimates of the time profiles of earnings. Because the earnings observations were not available for later years of the working life, only the early years of the earnings stream could be satisfactorily estimated. Extrapolation over the [illegible] working life of the trend based on increments in earnings over the first ten years of work would probably have resulted in an over-estimate of the future earnings, as there is some ground for believing that [illegible] working years exhibit the largest annual increases.

In order to avoid this possible source of over-estimation it was assumed that after time t' the annual increment in earnings was one half of that estimated from the observed data, and after time t'' there were no annual increments.[2]

In a number of cases the estimates were arrived at by a different method.

The estimate of earnings for the output of the Technical Training Schools was made on the basis of a sample of the employment

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1. This is clearly revealed in U.S. Census data. Cf. Gary Becker, Human Capital, p. 140.

2. For primary education t' is 10 and t'' is 20; for secondary level [illegible] and 25, and for higher [illegible]

records of recent graduates of these schools.[3] Estimates of the earnings profile for secondary school failures and dropouts after class IV are based on starting salaries yielded from the sample survey and an estimate of the annual increments based on the other time profiles.[4]

The time profiles of earnings for all activities making deliveries directly to the labour market appear in Table No.3.2. In order to estimate the income terms appearing in Table 4.1 the present values (at 5 percent) of each of the income streams appearing in Table A6 3,2 were computed. The income figure for each type of education ($Y_j^{P_j}$) was then computed as a weighted average of the present value of the earnings stream of the various parts of the product mix (i.e. dropouts, failures, and passes) weighted by the fraction of output expected to occur in each category.[5] The weighted averages appear in column 2 of Table 6.4.1.

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[3] These records are maintained by the Student Welfare Officer, Ministry of [illegible]

[4] [illegible] weighted average of product [illegible] and sales

TABLE A8.3.1

Estimating Equations for the Time Profi[illegible]re Earnings[a]

Number of Observations	Intercept (Starting Earnings in £'s)	Level of Significance of Intercept	Regression Coefficient of Time (Annual Increments in £)	Level of Significance	Correlation Coefficient	Level of Significance of	Standard Error of Estimate [illegible]
(2)	(3)	(4)	(5)	(6)	(7)	(8)	
47	319	.99	11	.99	.583	.99	15
44	259	.99	21		.518		
18	397	.99	20	.90	.212	.90	
112	1218	.99	47	.99	.377	.99	
67	1328	.99	68	.99	.482		16

a. The value of the Durbin-Watson statistic for all of the equations indicates that the hypothesis of independently distributed error terms should not be rejected.

b. The University earning streams were estimated separately for graduates of science and technology subjects and arts and social studies subjects [illegible] the intention of exploring a number of problems concerning the balance between various courses of university study. The average of the two benefits streams was used in the estimation of the objective function coefficient for university study. This procedure reflects the assumption that over the planning period the university output will be divided equally between the two different fields of study. If present government plans to increase the output of science and technology graduates to seventy-five percent [illegible] the total are successful, the net benefits figures used would represe[illegible] underestimate. (National Universities Commission, Report, p. 42.)

Source: see t[illegible]

Table A-5

Estimated Time Profile of Earnings [in $]

Year of entry into Activity (1)	Primary[a] (2)	Secondary Class I (3)	Secondary Pass (4)	Technical Training School (5)
1				0
2				0
3				0
4		147		173
5		159		187
6		171	259	201
7		183	280	215
8	0	195	301	229
9	119	207	322	243
10	130	219	343	257
11	141	231	364	271
12	152	243	385	285
13	163	255	406	
14	174	267	427	
15	185	279	448	
16	196	291	469	
17	207	303	490	
18	218	315	511	
19	223	321	532	
20	228	327	553	
21	232	333	564	390
22	238	339	575	397
23	243	345	586	404
24	248	351	597	411
25	253	357	608	418
26	258	363	619	425
27	263	369	630	432
28	268	375	641	
29	268	375		
		375		
		375		

[illegible]

[illegible] under the auspices of [illegible]
[illegible] in Colombia for [illegible]
by the [illegible] in [illegible]
August 1, 1964. [illegible]

TABLE 26.3.2 (cont.)

Year of Entry into Activity (1)	Form VI (6)	University Arts & Soc. Stud. (7)	University Sci. & Techy (8)
1	0	0	0
2	0	0	0
3	397	0	0
4	417	1218	1328
5	437	1265	1396
6	457	1312	
7	477	1359	
8	497	1406	2600
9	517	1453	
10	537	1500	1736
11			1804
12			1872
			1940
			2008
			2076
			2144
			2212
			2280
			2348
			2416
	717		
	727		
	737	21	
	747	2134	
	757	2157	
	767	2180	
	777	2203	
	777	2226	
	777	2249	1624
30	777	2272	2858
31	777	2295	2892
32	777	2318	2926
	777	2341	
	777		
	777		

a. It was assumed, conservatively, that those who drop out of primary school prior to year six are no more productive than those who have attended school. The increment in earnings associated with primary education is based on an alternative earnings stream of £80 per annum. This figure is the average annual earnings of "unskilled workers" as enumerated by the Federation of Nigeria, Office of Statistics and the Ministry of Labour, Report on Employment and Earnings Enquiry, 1958, 1959, 1960, 1961, 1962 (Lagos: Government Printer, Chief Statistician, 1960, 1962; Ministry of Labour, 1963).

In view of the fact that [illegible] earnings of the unskilled is likely to be positively [illegible] average figure may overstate the alternative earnings [illegible] because of the relatively too high earnings in the early period. [illegible] more fundamental source of overestimate in this alternative stream of earnings is the possibility that the wages of unskilled labor [illegible] considerably above the social marginal productivity. If, to use an extreme example, it were assumed that the social marginal productivity of unskilled labor in rice were zero, the net benefits of primary [illegible] using a 5% [illegible] could be increased from £986 [illegible]

b. It was assumed that those who drop out of the university prior to the [illegible] secondary school prior to the [illegible] are drop[illegible] of the secondary school prior to the [illegible] are productive than those who did not enter the [illegible]

c. The estimated working life in years after graduation, is as follows: $L_1 = 36$; L_4, $L_6 = 34$; L_5, $L_9 = 30$; L_8, $L_7 = 3$[illegible]. The j subscripts refer to the activities as numbered in Table [illegible]. The figures are based on averages from life tables for three African states and the median age upon graduation from each activity. Cf. United Nations, Statistical Office, Demographic Yearbook, 1963 (New York: United Nations, 1964), Table 26, pp. 612-14. Comparable figures for Nigeria are not available, but some confidence can be given to these figures, as the life tables of the three countries exhibited very close similarity. The fact that life insurance companies in Nigeria use a slightly longer estimated life suggests that these figures may be somewhat too low. This position is further supported by the fact that the life tables refer to the general population which in most cases has little or no access to professional medical care. The educated elements in the population are generally better informed on health practices and have closer access to medical services and thus should be expected to have a longer life expectancy. Errors in L have a very minor impact on the discounted stream of benefits. For example, correction for an assumed under-e[illegible] rate of six years (an error of [illegible]%)

Appendix 6.4. The Linearity of the Objective Function

The coefficients of the objective function used in this model are based on existing earnings differentials and are regarded as being independent of the levels of output of the various educational activities. The appropriateness of a linear objective function based on existing income differentials may be questioned on two main grounds.

First, the marginal productivity of a given educational output may depend on the stock of the stock of labor with a similar educational background. Second, the quality of the educational outputs in terms of skills and modes of behavior acquired in school may depend on the number of students admitted to each type of institution.[34]

The importance of the first [illegible] depends on the elasticity of the demand [illegible] various types of educated labor. Here the demand curve [illegible] the problem [illegible] correspondence between the [illegible] and it [illegible] would [illegible] wise. While the assumption of infinite elasticity of demand [illegible] mainly a [illegible] there probably good grounds for thinking that [illegible] demand curves types of labor as defined in this model are fairly elastic over the relevant range. With the possible exception of the [illegible] choc

outputs, the types of labor ... characterized by differences in the level of general education rather than in specific occupational skills. The elasticity of demand for labor with a broad general education is probably considerably higher than for labor with a specific occupational training.[35]

The present composition of the Northern Nigerian labor force and the high degree of inter-regional labor mobility lend support to the position that the marginal productivity of a given type of labor is not likely to be significantly affected by the levels of educational output generated by solutions to the model. Requirements from the stock of each type of labor in the North depend in large degree on the ... labor to each category. This phenomenon arises because of the large number of persons born outside of Northern Nigeria who are presently employed in the North.[36] The outward mobility of much of the educated labor in the North is attributable to two sources. First, political pressures have

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35. To the degree that a course of general education increases the trainability of a worker it also increases his substitutability with other labor inputs, and hence the elasticity of demand.

... Nigerians occupy only 42% of the total positions for university graduates in Northern Nigeria. (Cf. Table 6.1.1.) Many of these Nigerians are of Southern Nigerian origin. For example, an unpublished study of management personnel in a sample of 45 private firms in the North undertaken by Mr. Quinn McKay at the Institute of Administration, Ahmadu Bello University, reveals that only 40% of the Nigerian personnel in managerial and ... category ... are of Northern ori...

... education, Kaduna.

... have been checked wherever ... from other sources ... the unskilled labor ... senior administrative, clerical and professional ... positions are ... Table 6.1.1.

given rise to a policy of "Northernization", that is, the replacement of non-Northerns by Northern labor where supply conditions permit. Many of the positions presently held by these non-Northerners are likely to be made available to the Northern labor as [illegible] Northern educational system reaches a sufficiently high level [illegible] Second, voluntary inter-regional movements of labor can be expected to limit [illegible] movements in the earnings of each type of labor. Most of the non-Northern Nigerians originally moved to the North to take advantage of regional wage differentials. If the wages [illegible] were to be forced [illegible] an increased supply of educated Northern labor many would leave the North. A major fall in the earnings of any type of labor in the North would be accompanied by a reduction in the available stock through withdrawal of non-Northerners, and an equilibrating upward pressure on earnings. Thus given a high degree of labor mobility the extent to which the earnings accruing to any major type of labor [illegible] is limited by the cost (and inconvenience) of moving.

A second source on non-linear [illegible] is the "pool of ability" problem, namely the [illegible] that the average learning aptitudes of the student body will be inversely correlated with the [illegible] aptitude of the student intake. The pool of ability [illegible]

is dependent on variables which are not correlated with the future economic productivity of the student. The present Northern Nigerian selection methods at both the post primary and post secondary levels are probably to a large extent unrelated to variables closely associated with future economic productivity.[38]

In view of the apparent low correlation of results on entrance examinations with performance in school there is good reason to assume [illegible] correlation between selection and future [illegible][37]

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38. This view is based on informal personal investigation, and on the work of the Nigerian Aptitude Testing Unit in evaluating the validity of the selection methods.

37. Numerous Nigerian and foreign educators have commented on the arbitrariness of present selection processes. Cf. Paul W. Eberman and Howard E. Wakefield, "An Evaluation of Teacher Education in Northern Nigeria, 1962" (AID, 1963), p. 29 (Mimeographed); University of Wisconsin, "The Expansion of Teacher Education in Northern Nigeria, 1961 - 1970", Report of a study performed by the University of Wisconsin under contract [illegible] the Agency for International Development, 1963, p. 35, [illegible]graphed); Michael Goldway, Report on the Investigation of [illegible]nal Education in Eastern Nigeria (Jerusalem: State of Israel, 1961), p. 10; [illegible] et. al., Report of the Committee for [illegible] System of Eastern Nigeria (Enugu: [illegible], 1961), pp. 50-51; UNESCO, "Report [illegible]

Although increased production of any given type of education can be expected, ceteris paribus, to be accompanied by some downwards movement in the expected marginal productivity of the output, this movement down along the demand curve for labor is likely to be offset to some extent by a rightwards movement in the demand curve induced by growth and structural change in the economy. A crude estimate of the magnitude of the rightwards shift in the demand curve for primary, secondary, and university educated labor is presented in Table 6.2.1.

It is the absolute income differentials rather than the relative incomes of the educational outputs which are important in this analysis, and as long as the economy is experiencing an increase in average product per worker, constancy of the absolute income differentials is consistent with a narrowing of the relative incomes. Evidence from the U.S. suggests that despite large increases in the median educational level of the labor force the absolute earnings differentials between secondary and higher education have increased substantially since the 1930's.[41] If the Nigerian experience of the next thirty years repeats the U.S. pattern since the 1930's, my estimates of the present value of the educational output are significantly underestimated.[42]

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41. Herman ... earnings in ... Education ... Capital ... (December ... 1960) ... no. 4, 352-386.

42. ... on the U.S. record ... that this per... differentials. For ... Human Ca...

A comparison of the changes in the stock of educated labor induced by the enrollment levels yielded by solutions to the model with the rightwards shifts in the demand curves estimated in Table 6.2 indicates that the growth of demand for educated labor will be adequate to absorb the educational outputs at close to or higher than the existing levels of earnings.[43] Tests of the sensitivity of the model to changes in the marginal productivity of educated labor induced by changes in supply indicate that in this particular case the degree of distortion introduced by the use of a linear objective function is small.

7.1 The Constraint Vector.

Recall that the resource use constraints are written in terms of flows for intra-educational deliveries of continuing students and in terms of stocks for teachers. The total availability of students for the pursuit of further education depends on the previous year's output of the institutions producing students with the necessary prerequisites. The availability of teachers in the system depends on the amount of them produced since the beginning of the planning period, plus the amount of the original stock still available to the system, minus the total required use of the teachers in completing the education of those trained in the education system prior to the planning period. Thus where j is defined as a stock, the total availability of resource j in time t, B_j^t is:

7.1.1
$$B_j^t = \sum_{p=1}^{t-s_j} g_j X_j^p + B_j^1 (1-d_j)^{t-1} - \sum_{o=1}^{n} \sum_{i=1}^{o} \sum_{p=t=s_i}^{o} a_{ji}^t X_i^p$$

and
where j is defined as a flow

7.1.2:
$$g_i X_j^{t-s_j}$$

wing ... ation ... used

... stock of labor educated ... is ... of Southern Nigerian ... suggests that ... number of wage and salary ... with ... high ... the ... wage ... for ...

d_j = the expected annual rate of retirement from the teaching force for teachers of type j expressed as a percentage;

a_{ji} = the minimum input of resource j to accommodate one student at activity i;

g_{ij} = the fraction of the total admissions to activity x_i which is expected successfully to complete the course and to find employment;

B_j^0 = the total amount of resource j available at the beginning of the planning period.

The exogenous elements in this expression, namely the last two terms, comprise the parameter in the constraint vector pertaining to resource j. Thus:

$$7.1.3 \qquad B_j^t = B_j^0 (1-d_j)^{t-1} \sum_{i=1}^{n} a_{ji} g_{ij}$$

Table 7.1 presents the data used in the estimation of the B_j along with the final estimates.

As was suggested in section 3.3, administrative, political and other aspects of the planning problem may impose upper and lower limits on the values which educational activities may assume. For most major types of institutions there is an upward limit to the rate of growth of enrollments which arises from the [illegible] involved in arranging for the [illegible]

[illegible]

[illegible] can be made in the case of decreases in the [illegible] however, that a [illegible]

TABLE 7.2.1

Estimation of the Constraint Vector

	2	3	4	5	6	7	
	32,698	38,589	48,580	66,369	71,758	75,084	
3	615	642					
	7,820	9,000	8,695	8,426	8,148	7,894	
	3,979	3,420	2,738	1,862	817		
	(4,110)	(3,606)	(2,962)	(2,074)	(943)		
	3,841	5,580	5,960	6,554	7,331		
	(3,710)	(5,389)		(6,342)	(7,205)	(7,894)	(7,8
616	935		1,365	1,530	1,00	00	
	2,848			2,613	2,558	2,468	2,402
	2,034	1,68		1,262	936		
	(1,828)	(1,5		(901)	(409)		
	814	870	1,011	1,351	1,602	2,468	2,402
	(1,020)	(1,189)	(1,398)	(1,712)	(2,129)	(2,468)	(2,402)

1.1 continued

	3	4	5	6	7	8
		356	339		309	294
	106	84	51	23		
	244		288	301	308	294
80	110	179	177	177	176	176
	3,577	5,063	6,511	8,244	9,957	11,530	12,420
		57	67	77	87	97	107
	29	12					
	14	35	57	67	77	87	97	107
	409,165	421,082	435,000	448,800	460,807	472,725	488	504,500

TABLE 7 (1.1 continued 2)

1	2	3	4	5	6			
	545	625	705	785	865	945	1,025	1,1
	358	267	154	81				
	154	358	551	704	864	945	1,025	1,0
	212	212	212	212	212	212	212	212

t and notes (following page).

Notes to Table 7.1.1

a. Estimated [illegible] activity j are based on the 1964 enrollments in classes 2... [illegible] primary school output is corrected for wastage using [illegible] rate [illegible].

b. Gross number available is equal to the surviving initial stock plus the expected outputs resulting from the enrollment of students prior to p=1. The surviving initial stock is defined as $B_j(1-d_j)^{t-1}$ where d_j was set equal to .[illegible] for graduate teachers [illegible] teachers, and at .05 and .03 for grade III and [illegible] teachers. These low rates of attrition for the relatively less well qualified teachers reflects the rather low alternative earnings which are available [illegible] outside of the educational system.

c. Requirements for [illegible] are the teachers necessary to complete the [illegible] of students admitted to the system prior to p=1. These requirements are based on the estimated numbers of continuing students in each year and the teacher input coefficients in Table 5.3.1.

d. The figures in parentheses were used in only one solution of the model, and are based on the assumption that the composition of the primary school staff is unchanged over the 8 year planning period.

e. The available output of form six leavers includes an estimated 83 students who will pass the General Certificate of Education (Advanced Level) in years 1964 and 1965. The General Certificate of Education (Advanced Level) is roughly equivalent to the Higher School Certificate awarded to successful Form VI students.

f. Estimates of the numbers of NCE and university graduate teachers available include those expected to return from abroad. These estimates were based on figures supplied by the National Students Register (Federal Ministry of Education) and the Ministry of [illegible] Government, Northern Nigeria.

g. It is assumed that the very small number of Nigerian graduates [illegible] system are [illegible] to teaching the students who enter [illegible] system during the [illegible].

[illegible] total [illegible] is based on the [illegible] total social [illegible] number [illegible] growth rate of 7 [illegible] nt. The 7.5 [illegible] the 10 percent [illegible] annual rate [illegible] the period [illegible]-1963, [illegible]

j. The size of the 6 year age group is estimated on the basis of Jefferson Eastmond's figures in "A Progress Report on Efforts to Attain the Enrollment Goals of Primary Education in Northern Nigeria" (Kaduna: Ministry of Education, July, 1964). (Mimeographed.) The estimates employ a rate of population growth of 3 percent. Because it is thought to be unlikely that the percentage of female students in primary schools will increase over the period the figures in the table represent the maximum student intake with the existing sex ratio. The imposition of an upper limit on the rate of expansion of primary education over the period has rendered this constraint redundant.

k. The limitation on the number of foreign university graduate teachers and foreign well qualified non-graduates (equivalent to NCE teachers) which can be imported is imposed for both political and administrative reasons. The limit for graduates is based on the number actually in the system for 1964 and the average annual increment over the years 1961-1964. The figure for well qualified non-graduates is held constant in view of the political difficulties which would be involved in expanding the employment of foreigners in jobs for which a fairly large number of Nigerians are qualified.

the enrollments will be considred as realistic policy alternatives by the responsible government officers. Upper and lower bounds have thus been imposed, as follows:

7.1.4a $X_j^p \geq .7X_j^{p-1}$ for j = 1, 5, 8, 9

7.1.4b $X_j^p \leq 1.3X_j^{p-1}$

TABLE 7.1.2

Upper and Lower Bounds on Activi[illegible] in Year 1

Activity	Lower Bound	Bound
Primary	63,000	120,000
Secondary	1,800	3,500
Form VI	140	260
NSTC	[illegible]	180

[illegible]though the figures .7 and 1.3 are ba[illegible] recent change[illegible] enrollment [illegible] plausible in [illegible] present situation [illegible] Northern Nigeri[illegible] ry nature of t[illegible] itions should [illegible] r ye[illegible] 4) ar[illegible] ively [illegible]

[illegible] in period p

7.2. An Efficient Pattern of Resource Allocation in Education.

The solution presented in this section is based on the present structure of the educational system and on the present educational technologies and their planned future movement. The activity levels and shadow prices yielded by the model are presented in Table 7.2.1 as solution 1.

With respect to the activity levels a number of interesting results emerge. First, because of the planned upgrading of the primary school teaching staffs, the teacher training activities are run at relatively high levels. The increase in the grade II teacher input coefficient over the planning period is particularly important in that the consequently high activity levels for the grade II teacher training course in the early years requires the withdrawal of large numbers of grade III teachers from the primary school system for admission to the grade II teacher training colleges. In the first two years alone [illegible] grade III teachers are admitted to the grade II course.

[illegible] can assume
The withdrawal [illegible] of grade III teachers

TABLE 7.2

Resource	Year	1	2	3	4	5	6	7	8	10+
4. Secondary Teachers										
a. Grade II Teachers		1009	1100	36446	47380	61195	80073	104095	135324	572015
a) gross number available				4345			6641	7331	8021	42490
b) requirements for Secondary Schools further upgraded over				981	687	481		235	165	5945
5. Grade II Teachers Trainees				67	4694			5376	6066	19486
6. Technical Teachers										
a. Level VI Teachers										
Form 6			127	89	62		210			1246
Northern Secondary Teachers Col			198	257	321	300	350			2098
9. University			149	104	73	51	35			07
			479	365	334		207	416		2157
			212	163	212		36	212		954

(Z*): 457,399,312

Resource	Year
8. Nigerian Certificate of Education Teachers	
a) gross number available	

stock

TABLE 7.2.1 (cont.)

SOLUTION I SHADOW PRICES

	1	2	3	4	5	6	7	8
10. Total expenditure (000's)								
11. Senior [illegible] teachers								
[illegible]								
Primary [illegible] ers								
[illegible]	4,153	4,989		9,371				17,78[illegible]
Grad[illegible]								82,86[illegible]
Se[illegible] school leavers		130,629			25,216			46,109
[illegible]	168,605	167,879	167,131	9,051	8,453	7,862	7,156	6,653
[illegible]	755	723	492,076	649	19,668		536	87,95[illegible]
[illegible]	268,408	795		718	584	473,034	593	55[illegible]
[illegible] ers								
[illegible]								
Foreign [illegible] workers								
[illegible] imported [illegible]								
[illegible] instruments								

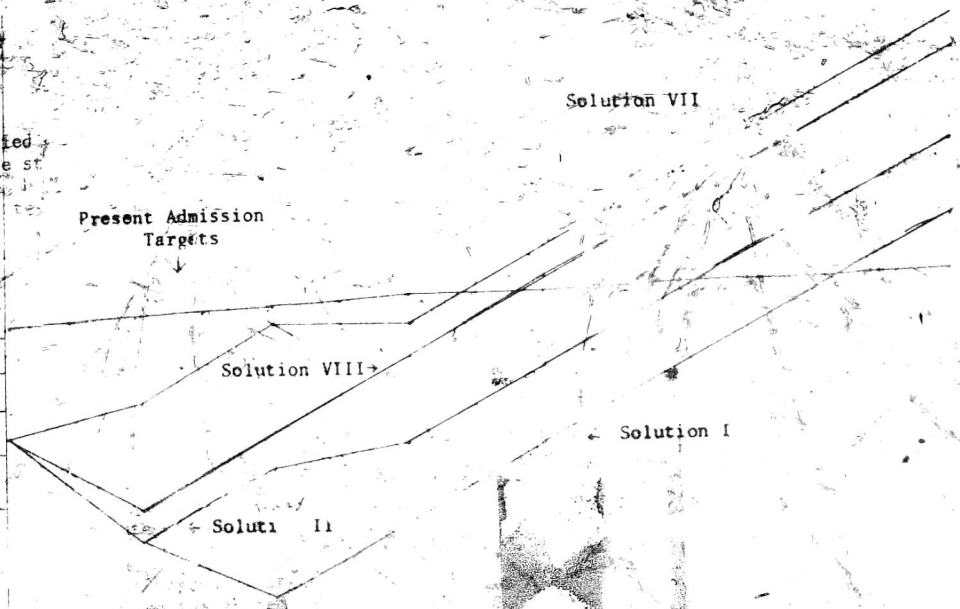
TABLE 7.2.1 (cont.)

SOLUTION I SHADOW PRICES

1	2	4	5	6	7	8
		163	211	195	60	
	29,972	31,825	178			
276,573						
		491,396	19,039			87,446
1,056	1,003					
23,934	17,820	32,467	25,204	14,877	257	
	10,682	22,210	38,210	60,604	35,810	95	82,909

FIGURE 7.2.14

PRIMARY SCHOOL ADMISSIONS
(1964-71)



pronounced decline in admissions in the early years of the period makes possible a rapid rate of growth for the years three through eight.[2] Both the early reduction in enrollments and the later rapid rate of growth in enrollments deserve comment. With respect to the first, the behavior of the primary education activities and their interaction with the relevant teacher training activities (grades II and III) points to a serious incompatibility between the government's expressed goal of a significant improvement in the qualifications of the teaching staffs on the one hand, and the goal of rapid enrollment increases on the other. Given the proposed changes in the teacher output coefficients the maximum feasible admissions into primary school years one and two is 123,800 or [illegible] per year. This indicates that regardless of the optimizing process, adherence to the quality improvement aim necessitates a short run but drastic reduction in enrollments.[3]

---

2. The implementation of such a pattern of growth could have serious political repercussions. In particular, it is not clear that the present government would be willing to bear the political costs of such a drastic curtailment in admissions during the years 1964 to 1969. (It is only in 1970 that the primary school [illegible] exceed the level actually achieved in 1964.) The possibility that the growth path indicated would be politically unacceptable suggests that [illegible] the earliest time at which [illegible] has been set at [illegible] level or [illegible] the relevant [illegible]

The high rate of increase in admissions after year three is equally remarkable in view of the conviction among many knowledgable people in the field that a justification for rapid primary school expansion must be sought in the sphere of politics rather than economics. Consideration of the data in the general framework of this model suggests that expansion of primary education is as rational economically as it is popular politically. The present value of benefits and costs as indicated in columns 4 and 5 of Table 6.4.1 suggest a crude benefit-cost ratio [(Y-Y')/C] of 16.9.[4] Moreover, [illegible] benefits produced by the primary school system per direct and indirect unit of input of the most scarce teaching inputs (NCE and graduate teachers) is undoubtedly the lowest in the educational sector, with the possible exception of higher education.

While it would be unwise to generalize the undoubtedly strong [illegible] on resources employed by primary education in this particular application of the model, the results do suggest that there is much to be gained by using an approach which allows a consistent treatment of benefits and costs and a general [illegible] analysis of the complicated interrelations within the [illegible] system. [illegible] problem necessitates [illegible] For the first few years [illegible] two years the lower [illegible] [illegible] and [illegible] [illegible] [illegible] total number 92,000. Thus, the [illegible] 7.2.1

training ... primary school system ... clarified by an inspection of solution I. The discussion above and the data in Chapters 5 and 6 suggest a number of measures which might contribute to a more efficient pattern of allocation in these three activities:

a. a reduction in the number of years required to complete primary school (cf. solution II, Table 7.3.1);

b. an attempt to reduce the extraordinarily high failure rates in grade II teacher training colleges (cf. solution VI, Table 7.5.1);

c. postponement of the improvement in the primary school teaching staffs (cf. solution VII, Table 7.6.1);

d. an attempt to retain a larger number of primary school teachers within the system and to recruit ex-teachers back into the system (cf. the discussion at the end of ...

A second interesting aspect ... in solution I is that secondary education ar... bound the primary school ... to the primary school system ... period, by ensuring the ... primary education is ... the first and thereafter ...

... to primary school in 1963 was ... substantial. See Figure ...

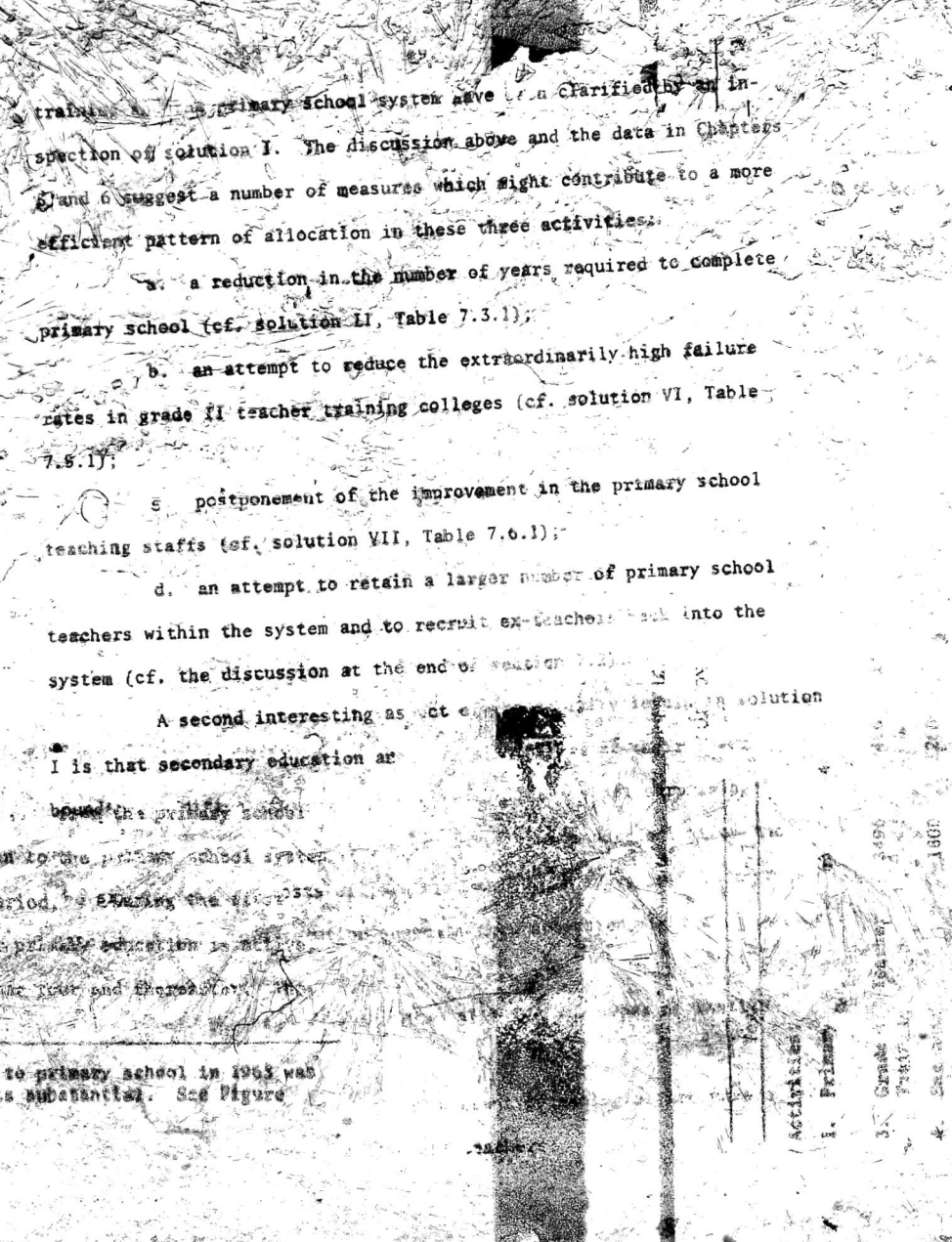
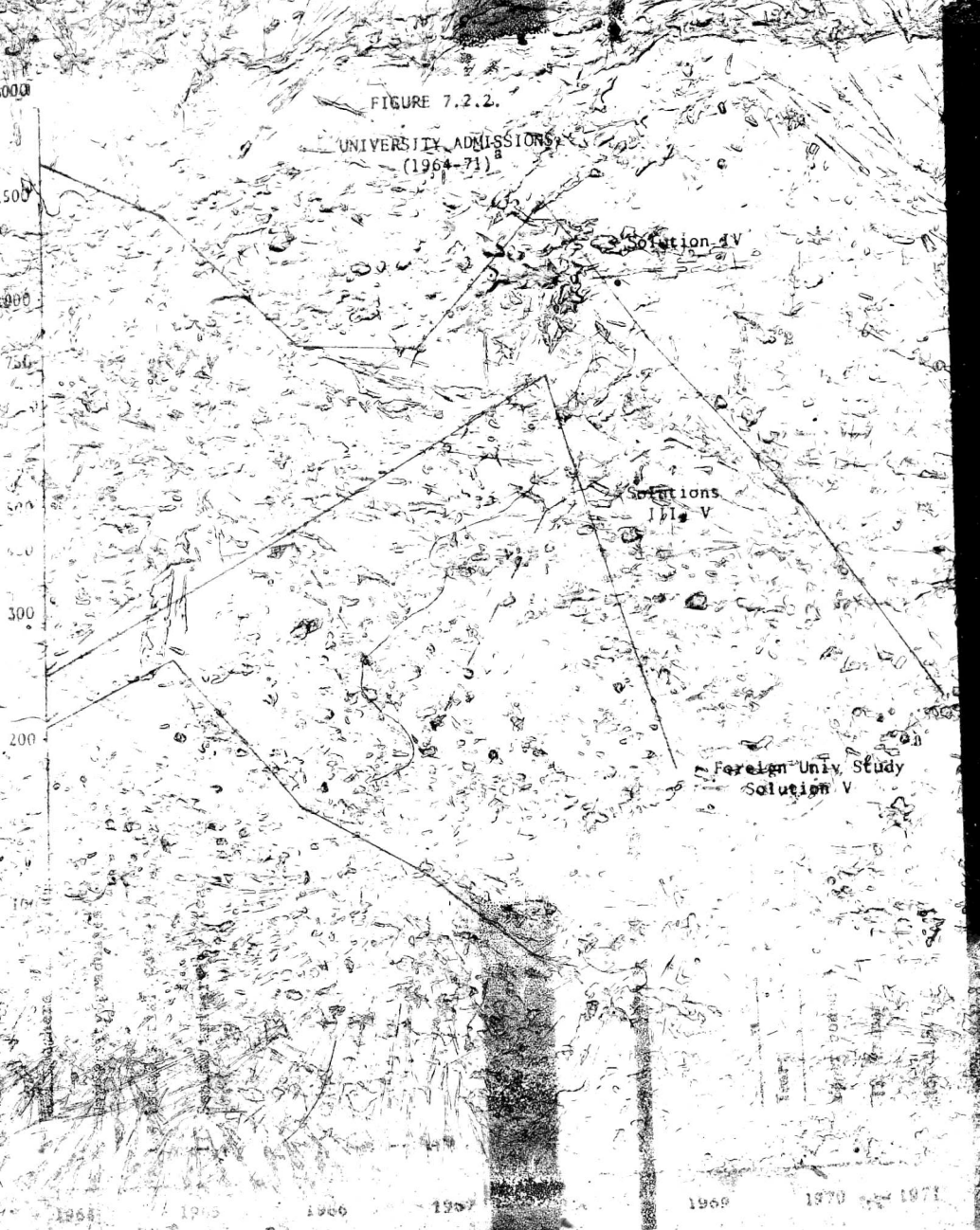


FIGURE 7.2.2.

UNIVERSITY ADMISSIONS
(1964-71)



education is unnecessary in Northern Nigeria, but rather that given the present production processes and composition of output, the benefits are not sufficiently high to justify the costs. A number of possible explanations can be offered.

First, the cost of operating the present technical training schools is extraordinarily high: capital cost per student [illegible] are 2.4 times those at the most expensive non-technical institution at the secondary education level, and recurrent social costs are 2.5 times as high.[6]

Second, the demand in the Northern Nigerian economy for the highly trained technicians now being produced is limited to a few government ministries and a handful of industries. A large number of the past graduates of the technical training schools are presently holding jobs requiring skills far below those developed in the course of their education. As a consequence of this "over training," many of the students leaving the technical training schools can be expected to be employed in jobs in which their marginal productivity is far lower than the minimum necessary to justify their substantial costs of production.

The following alterations in the technical education system should be considered:

[illegible] course to a terminal

[illegible]

1964 1965

b. the investigation of the possibility of significant reduction in the costs of the technical training schools,[7]

c. the possibility of greater reliance on the in-service training programs run by private industry and the public corporations could be investigated.[8] Were this plan adopted the formal educational system would concentrate on providing general education designed to raise the level of trainability of the student rather than to equip him with specific occupational skills.

Finally, the activities importing graduate teachers and well qualified non-graduates are run at positive levels throughout and for a number of years are constrained by their upper bound.

It should be noted that the activity levels for the final two years of the grade II teacher training course and form six, and the final three years of the Northern Secondary Teachers College and the grade II course have been exogenously constrained not to fall below the levels at which they appear in the solution. The levels of these terminal conditions were determined on the basis of preliminary previous results of the model, so as to insure at least as high a level of output from these activities in the immediately post terminal years as in the pre-terminal years. The method has failed to achieve a smooth

growth path for these activities, but the minimum requirement has been met, namely, provision has been made for teachers and continuing students in the post terminal years.[9]

Examination of the shadow prices yields the following interesting results. First, the shadow price of total social expenditure is zero throughout. One must be careful, however, in drawing inferences from the failure of the total expenditure constraint to become active. Strictly interpreted, the value of the shadow price suggests that as long as there is some product associated with expenditure in other sectors of the total allocation to the educational system should be increased, which seems paradoxical. However, in view of the [illegible] associated with many educational activities, the magnitude of the net benefits generated by the solution.[10] The conclusion warranted by the zero shadow price associated with the total social expenditure constraint is that given the present rigidities and structural bottlenecks, the system cannot profitably use the total budget allocated to it. The high shadow prices associated with a

[illegible]

9. It will be shown in Appendix A7.1 that changes in the terminal conditions produce only minor effects [illegible] part of the period.

number of the boundary conditions on both [illegible] ing act. The teacher importing activities suggests that a considerable portion of the social expenditure allowed to the educational system, but unused in Solution I, could be directed to breaking some of the administrative bottlenecks in the system.[11]

Second, for those years in which the constraint on the maximum importation of foreign teachers is not active, the shadow price of graduates and well-qualified non-graduates in the system is identical to the present value of the cost of importing them. Thus, efficiency condition 2.4.11b is met. The possibility of importing foreign teachers places a ceiling on the shadow price of these teachers in the system.[12] In those years when the constraint on the maximum number of foreign

---

11. An approach to the elimination of one of the rigidities is outlined below. The total direct cost of operating the primary school activity for the seven year course is [illegible]. The assumption of constant input coefficients implies that any number of students [illegible] upper bound can be accomodated at the same [illegible] ond the upper bound are infeasible. [illegible] hich the admission of students beyond the upper [illegible] t a considerably increased cost, [illegible] presents the [illegible] velopment [illegible] into the primary school [illegible] ...ork is not [illegible] ...ndividual [illegible] ...ver relevant [illegible] ...nuous [illegible] ...ance for [illegible] ...nservative assumption con- ...dropouts and a liberal [illegible] ...tions.

...ly con... ...ew of the relatively ... ...ers not ... ...Teachers. This ... ...ly intensive in the us...

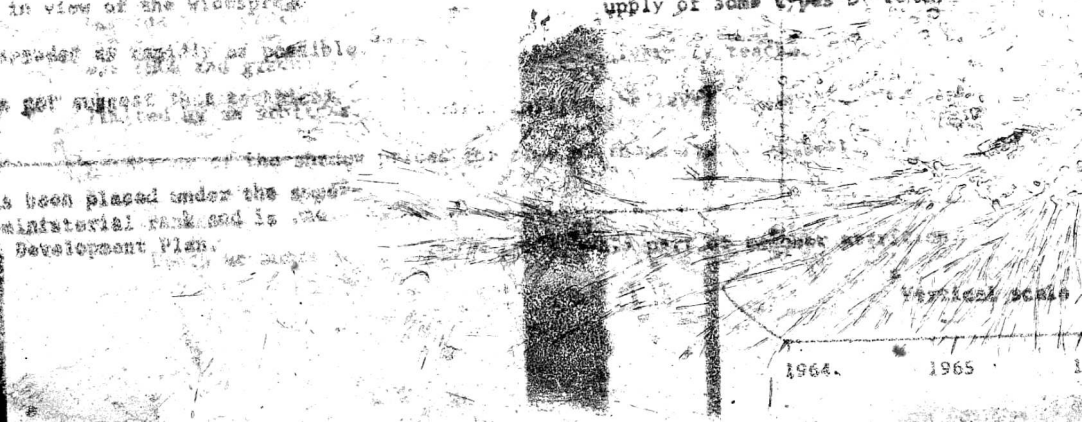
teachers imported is active, the shad[illegible]ring to this constraint reflects the effect on total net benefits [illegible] availability of an additional foreign teacher. Thus, the shadow [illegible]ce is the opportunity cost of setting the maximum levels of importation at their present levels. The magnitude of this opportunity cost (especially for well-qualified non-graduates in p=5...8), suggests a reappraisal of the levels at which their constraints have been set.[13]

Third, the primary school teacher training bottleneck is reflected in the high shadow prices of grade III and grade II teachers during the early years, and especially in year two. Similarly the high shadow price on form six leavers is an indication of the serious shortage of students with university preparation.

It is worth noting that serious shortages arise only for those resources which are not internationally traded, and which consequently are characterized by short run inelasticity of supply.[14] This result

The shadow prices for grade III and/or grade II teachers are positive in years 1, 4, 5, and 8. The fact that in a number of cases the constraint on one type of teacher is binding, while the other is not, arises from the assumption of zero substitutability between the two types of teachers. The very high level of some of the shadow prices for these teachers suggests that the optimality of the existing and planned production functions should be tested both with respect to the possibilities of substitution between grade II and grade III teachers, and substitution between teaching and non-teaching inputs. A method for the analysis of this problem has been developed in Appendix 3.1 and is applied in section 7.7 (cf. solution VIII, Table 7.7.1).

Fourth, the high shadow prices of some types of teachers suggests a reconsideration of the nature of the supply functions for these factors. The model has been constructed on the basis of supply functions which yield a fixed supply price up to the total specified by the element of the constraint vector, and an infinite supply price thereafter. Recall that the limit for the supply of teachers includes [illegible] of movement of these teachers out of [illegible] upply of some types of teach



methods should be sought for expanding the relevant resource availabilities even if considerable cost is involved. The present supply functions for NCE teachers and graduate teachers (as depicted in Figure 7.2.3) illustrate the possibility of expanding the supply of resource at an additional cost. The vertical distance between the first and second segment of each function is the cost of importing. Additional steps could easily be added to represent the possibilities for further importation at the existing import supply price, plus additional costs of recruitment and possibly salary increments. The shadow prices generated by solution I suggest that expenditure should be directed towards expanding the availability of primary school teachers. A number of possibilities suggest themselves, for example, increased teachers' salaries, or bonuses, to lower the attrition rate, and if possible, to recruit ex-teachers back into the system.[16]

7.3. The Efficiency of Alternative Production Processes: A Five Year Primary School Course.

The first solution indicates that given the present methods of production and the likely future changes in the production processes the system is incapable of supporting rapid increases in primary school enrolments. One possible solution to this problem which [illegible] the shortening of

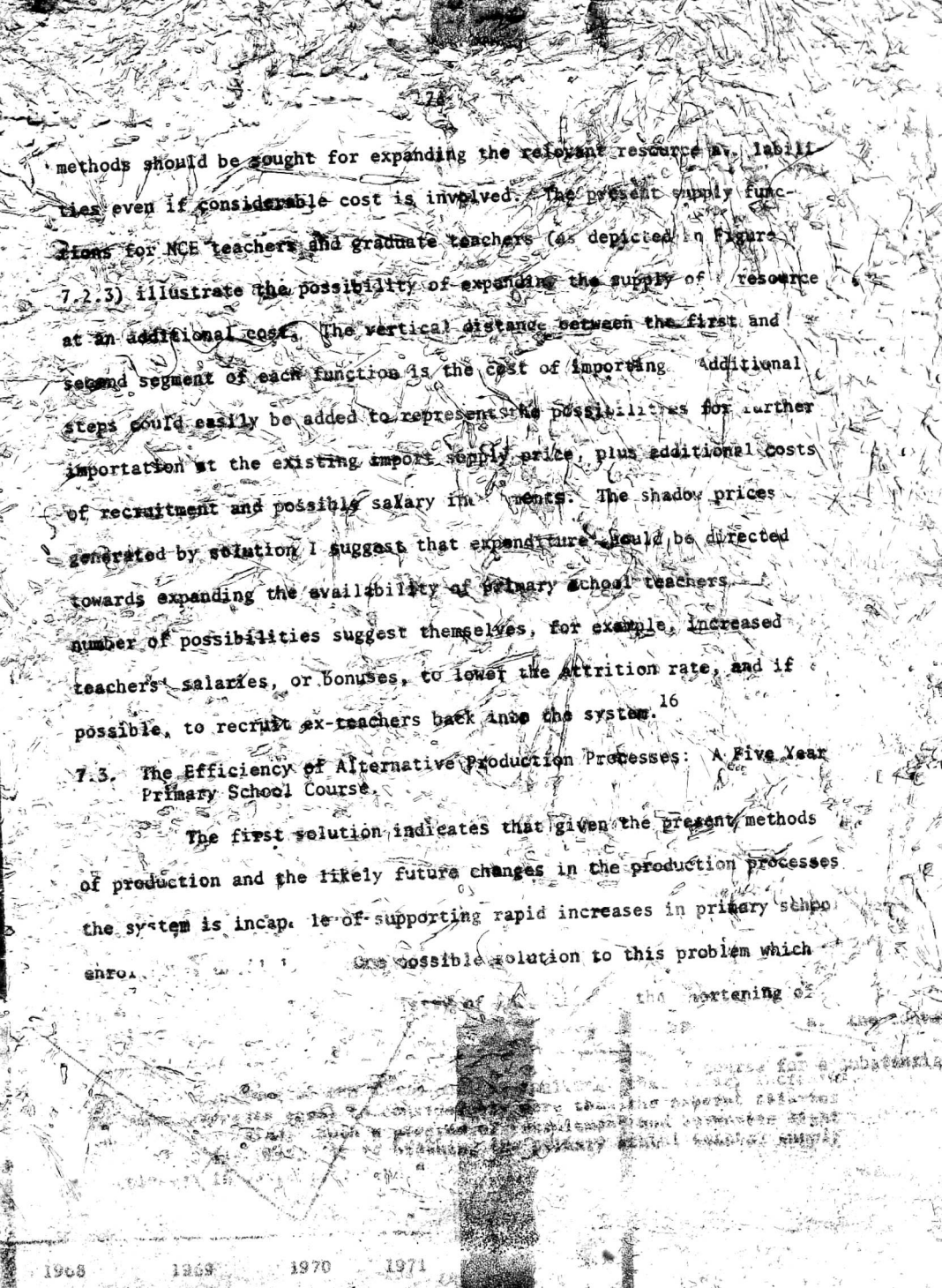
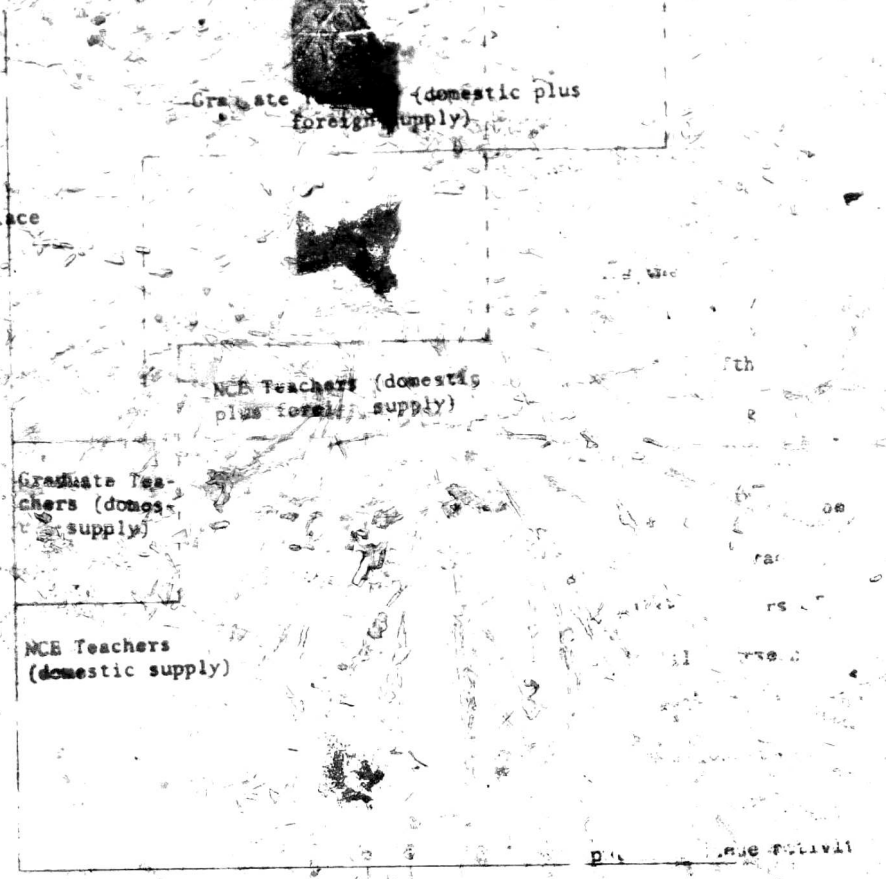


Figure 7.2.3
Supply Functions for Graduate Teachers and NCE Teachers
(year 2)



buildings an average annual intake 7/5 the size of present admissions could be accommodated. Second, even if the extreme assumption were made, namely, that teachers' salaries had to be increased proportionally with the number of school days per year, the total salary cost per graduate would obviously be unchanged. Third, the opportunity cost of using more of the student's time in education is impossible to estimate with any degree of accuracy, but the following considerations suggest that it is very minor.

a. Virtually no childr employed for wages before the age of 13.

b. Where family employ nt (in manor agricultural or household chores) is the alternative use f the student, it should be observed that the number of tasks suited to children of this age are limited, and that most families have access to the services of other children in their own or in relatives' families.

Fifth, the opportunity costs of using more teachers' time for education is equally difficult to measure. Very few teachers appear to get mporary employ ring the vacation periods. significant number of them use their vacation tim

buildings for a longer period during the year is zero. They are idle during vacation time.

To measure the economic implications of a reduction in the length of the primary school course I have introduced a new primary school activity for which the input coefficients for years 6 and 7 have been set equal to zero. The teacher coefficients in this new activity are otherwise identical to those in the seven year primary school activity. Capital costs per student place per annum remain unchanged. Yearly recurrent costs are increased so as to bring the five year total recurrent cost up to the figure for the seven year course. The total annual cost per student is £14.4 and the present value of net benefits for year 1 is £1068.

The effects of the introduction of a five year primary school course can be seen in solution II (Table 7.3.1 and Figure 7.2.1).

ing form six.

While considerable further work must be done on the qualitative aspects of the four year as opposed to the three year university course, we will accept as a working assumption the position that there is no significant qualitative difference in the two courses.

Input coefficients for the four year university course are identical to those of the three year course except that the input of students refers to secondary school leavers, rather than sixth form leavers, the costs and all other inputs extend into the fourth year, and the foregone earnings stream is that of the successful secondary school leaver rather than the sixth form leaver. The adjustment in the objective function coefficient resulted in an increase from £10,[illegible] to £14,320 for the coefficient referring to [illegible]

The main effects of the [illegible] year university course can be seen from an inspection of [illegible] (Table 7.4.1, Figure 7.2.2).

a. Total admissions to the university course are 2062, considerably higher than the 1010 shown in the previous solution.

[illegible] results of research by Dr. Babatunde Fafunwa, Head [illegible] University of Nigeria, suggests

TABLE 7.4..

SOLUTION III ACTIVITY LEVELS

	1	2	3	4	5	6	7	8	total
	63000	44100	57330	62345	81049	105363	136973	178065	728225
		2762	4051	8874	6718	6641	7331	8021	44398
	1800	1260	882	617	432	302	211	148	5652
	1246	1195	892	399	556	4162	5376	6066	20892
ng	[illegible]	61	[illegible]						[illegible]
y	120	156		265	344	300	350	400	2139
	52	378		80	432	558	437	224	2857
d									
	66		255	382	376	344	243	232	2037
			37	5	212	212	212	212	1082

TED BY THE SOLU

b. The present value of net benefits generated by the system shows an increase of £27.961,167, from £634,822,598 to £661,883,765.

c. The recruitment of senior university teachers is now the main obstacle to further university expansion. The shadow price of senior university teachers is positive for all years except 7 and 8; in all other years it is greater than £10,000. The magnitude of this shadow price indicates that additional expenditure on the recruitment of university teaching personnel would be justified even up to a point where the cost of recruitment exceeded the present salary of the teacher by a considerable amount.[22]

The university enrollments in solution III are far below those presently planned by the Northern Region Government and Ahmadu Bello University. A solution has been computed in which no restrictions are placed on the recruitment of senior university teachers (solution IV, Table 7.4.2). While the significant increase in the net benefits (from £661,883,765 to £720,371,413) indicates that a considerable expense would be justified for the recruitment of additional senior university teachers, there are strong [illegible] believing that the magnitude of the recruitment suggested in solution IV is unrealistic [illegible]

TABLE 7.4.2

SOLUTION IV ACTIVITY LEVELS

2	3	4	5	6	7	8	total
44100	57330	62345	81049	105363	136973	178065	724225
	4105	8820	6718	6641	7331	8021	4439
50	882	617	432	302	211	148	56
1135	1892	345	611	4162	5376	6066	
56	204	265	344	300	350	400	
	816	806	1357	724	438	224	
	248	319					
	23	78	212	212	212	31	

720,371,413

re even larger numbers of

possibilities are to lower the [illegible] ratios at the universities or to send students to universities abroad. Only the latter of these two possibilities will be considered here.[23] The parameters of the activities pertaining to foreign university study have been presented in Chapters 5 and 6. The effect of allowing foreign university study is illustrated in solution V (Table 7.4.3, Figure 7.2.2). namely:

a. The admissions to Ahmadu Bello University are unchanged while the number of students sent to foreign universities in years 1 through 6 exceeds the intake at Ahmadu Bello over the same period.

However, during years 7, and 8 the two university activities compete for secondary school leavers, and because the net benefits of foreign university study are somewhat lower than for domestic study [illegible] costs) foreign university study activity is curtailed [illegible] at two years.

TABLE 7.4

SOLUTION V	ACTIVITY LEVELS						
S_j	3	4	5	6	7	8	
	44100	57330	62345	81049	105363	136973	178065
	62	4051	8874	6718	6641	7331	8021
	1260	882	617	432	302	211	148
	1195	1892	399	556	4162	5376	6066
	615						
	156	204	265	344	300	350	400
	378	396	180	432	558	437	2
	325	422	549	714	165		
	139	255	382	293	152		
	48	37	145	212	212	212	212

THE SOLUTION (Z*): 691,702,593

TABLE 7.4.3 (cont.)

SOLUTION V SHADOW PRICES

	1	2	3	4	5	6	7	8
leavers								
avers	450	427						
	9,028		8,769	14				15,02
						10,770	10,596	10,16
		2,962,780		23,648			23,642	17,371
	755	723	680	649	408,728	2,427	2,371	703,436
	835	795	752	718	684	651		
	221,547	24,017	10,331	10,331	204,525	7,194		

system is increased £29,818,828 from £661,883,765 to £691,702,593. The total increase due to the introduction of the four year course and foreign study can be seen by comparing solutions II and V, namely an increase in the value of the objective function of £56,879,995.

7.5. The Economic Implications of Changes in the Efficiency of the Teaching Process.

Inspection of Table A5.4.1 will reveal that a number of the educational production processes exhibit extraordinarily high failure rates. While performance on terminal examinations can hardly be accepted as an ideal standard of the efficiency of an educational system, it does give some idea of the extent to which a production process is achieving the teaching goals which it has set for itself and judged those standards to be adequate. In grade II teacher training [illegible] the least [illegible] order [illegible] cations of [illegible] the grade II output coefficients were altered to reflect a pass rate of 80 percent. The results are presented in solution VI (Table 7.5.1). The pattern of enrollments in solution VI yields a net benefit figure of £29,293,584 higher than in the analogous solution [illegible] strictly speaking [illegible] of improvement [illegible]

TABLE 7.5.1

SOLUTION VI — ACTIVITY LEVELS

2	3	4	5	6	7	8	total
44100	57330	74528	96887	125954	163740	132637	758176
2742	1992	9808	8482	6641	7331	8021	45082
1260	882	617	432	302	211	148	5652
707	2139			1517	5376	6066	16405
615							1120
160	208	271	352	300	350	400	216
378	396	180	432	558	437	224	285
325	422	549	724	165			24
117	208	356	288	143			8
27		120	212	212	212	212	

JTION (Z*): 720,996,177

than E28 ... the educational system.

The increase in ... benefits is largely attributable to the fact that while both total primary school admissions and total admissions to grade III colleges are at levels somewhat above those in solution V, the total admissions to the grade II colleges were only 79 percent of the figure for solution V. While no attempt ... made here to suggest methods of reducing the failure rate at the grade II teacher training colleges, solution VI does ... that it would be worthwhile to devote considerable attention ... this problem.

7.6.. Economic Aspec... of the ... Trade-Off Between Quality and Quantity: The Case of Primary ... tion.

Up to th... ...mposition of the teaching staffs at the various educat... ...ons, and the change in the teaching staffs over time ... ...

... reflecting the greater net benefits ... for an university study.

... The present value ...

... to full time students of .06 (UNESCO, The ... Africa, Report of the Conference on the D... Africa, Tananarive, September 3-12,1962 (... ... the National University ... science and technology fiel... ... (1964) aggregate teach... Universities is .14.

the polic[illegible]

It is clear that the model allows the analysis of the effect of a given change of any one or any group of the input coefficients on the activity levels and shadow prices in the system. As an illustration of the type of [illegible] which can be performed, alternative to the planned improvement [illegible] the primary school teaching staff will be considered. We have [illegible]duced primary school activities for years [illegible]8 which embody no temporal change in the teaching input coefficients.[27]

Solution VII (Table 7.6.1, and Fig[illegible] 1) indicates the effect of this change:

a. [illegible] very rapid rate of growth of primary school enrolments which [illegible]lt in a total [illegible]ssion to primary schools of 1,075,566 [illegible] of the net

[illegible] lowering
[illegible] the Revolu-
[illegible] teaching staff
[illegible]her Education in
[illegible]er Education [illegible]
[illegible]83), p.71, re-
[illegible]ecommended a ratio
[illegible]r fields. (Repo[illegible]
[illegible]t Ahmadu Bello

[illegible]OGI

TABLE 7.9.1

	ACTIVITY LEVELS						
	4	5	6	7	8		
3000	91	95394	93699	121808	158351	205896	267683
122	5.16		4900	14185	6641	7331	8021
	1700	882	617	432	302	211	148
1153	861	1170	865	3845		5376	6066
	80	254	237	309	402	300	360	400
	252	134		821				
	250	303						
	167	287	421	269	362	302	343	47
	77	165	96		212	164	212	

THE SOLUTION (Z*): 943,038,303

the eight year period.

7.7. Substitution Possibilities in the Production of Primary Education.

Fixed input coefficients production functions are probably a relatively accurate representation of educational processes as they are viewed by most educators and planners. Nonetheless from a pedagogical point of view considerable substitution between educational inputs may be possible. The artificial nature of the assumed non-substitutability between grade II and grade III teachers has been pointed out in section 7.2. In addition, there may be considerable substitutability between inputs of some types of teachers and inputs of educational equipment. In this section I will use the methodology developed in Appendix 3.1 to explore some of the economic implications of factor substitution in the production of primary education.

The majority of teachers are used in the primary school system [illegible] work performed by each type of teacher is essentially [illegible] main difference being that the grade II teacher has had two years more training. Let us assume for the sake of illustration that a given body of material can be taught to a class in one hour by a grade II teacher, or in two hours by a grade [illegible] efficient assumption would be that in one hour a

We now define two new activities:

$X^{P}_{ii,iii}$ which transforms grade II teachers into grade III teachers at the rate of one grade II teacher per two grade III teachers

$X^{P}_{iii,ii}$ which transforms grade III teachers into grade II teachers at the rate of one grade III teacher per one half a grade II teacher. The cost associated with each activity is £50.

Analysis of the substitution possibilities between teaching inputs and inputs of equipment in the production of primary education requires an estimate of the marginal rate of substitution between these two types of inputs. Let us assume that the services of a grade III teacher are equivalent from the educational standpoint to the services of equipment and supplies the yearly cost of which is £300 [28]

We thus define a third activity $X^{P}_{eq,iii}$ which substitutes inputs of £ worth of equipment services for services of one grade III

---

28. Where the producing unit under consideration is a primary school of 150 pupils, the services of a grade III teacher might be equivalent to four additional text books and workbooks for each student, a radio, a film projector, a tape recorder, slide projector and ancillary equipment plus 25 wall maps, charts, and other visual aids. The total cost of the additional equipment would not exceed £600 [illegible] an average [illegible] of [illegible] years for this type of equipment the yearly [illegible] would be £300 [illegible] reduces the [illegible]

teacher.[29]

Substitution possibilities at the above marginal rates of substitution extend only over a limited range in the vicinity of the factor proportions described in chapter 5. The following boundary conditions have been introduced to reflect these limits on substitution.[30]

$X^1_{eq,iii} \leq 400$	$X^1_{iii,ii} \leq 200$	$X^1_{ii,iii} \leq 100$
$X^2_{eq,iii} \leq 350$	$X^2_{iii,ii} \leq 175$	$X^2_{ii,iii} \leq 90$
$X^3_{eq,iii} \leq 350$	$X^3_{iii,ii} \leq 175$	$X^3_{ii,iii} \leq 90$
$X^4_{eq,iii} \leq 400$	$X^4_{iii,ii} \leq 200$	$X^4_{ii,iii} \leq 100$
$X^5_{eq,iii} \leq 450$	$X^5_{iii,ii} \leq 225$	$X^5_{ii,iii} \leq 110$
$X^6_{eq,iii} \leq 500$	$X^6_{iii,ii} \leq 250$	$X^6_{ii,iii} \leq 120$
$X^7_{eq,iii} \leq 550$	$X^7_{iii,ii} \leq 277$	$X^7_{ii,i}$
$X^8_{eq,iii} \leq 600$	$X^8_{iii,ii} \leq 300$	

The applications of the introduction of th

Tab[illegible] 7.2.1.

[illegible] ACTIVITY LEVELS[a]

	4	5	6	7	[illegible]
[illegible]	4203	83464	108503	141054	183370	[illegible]
[illegible]	8011	7961	5724	6641	7331	[illegible]
[illegible]	882	617	432	302	211	[illegible]
[illegible]	[illegible]	1683	1738	5583	5376	[illegible]
[illegible]	[illegible]	293	381	300	350	[illegible]
[illegible]	[illegible]5	271	432	558	437	[illegible]
[illegible]	422	146	682	16	[illegible]	[illegible]
[illegible]	420	471	289	171	[illegible]	[illegible]
[illegible]	194	204	212	212	212	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]0	450	500	485	600

[illegible] and Form 6 are zero.

27. In all other respects the parameters of run V. In order to simplify the computations, extreme assumption that the quality of the teach future stream of earnings are unrelated.

TABLE 7.7.1 (cont.)

SOLUTION VIII SHADOW PRICES

1	2	3	4	5	6	
				8,948		
25	72,714	558				
	145,523	1,207	194,369	121	1,556	
755	8,528	1,590	11,366	31,759	9,390	30,7
38,861	795	1,759	12,571	1,262	651	
		1	14	1		
30,830	61,230		45,731	4,397	44,407	

TABLE I.7.1 (cont.)

SOLUTION VIII SHADOW PRICES

	2	3	4	5	6	7	
		1,856	1,972	2,375	1,499	842	
,137		56,995	57,167	60,834			
,410	3,879	2,706					
38,026							
ified	7,805			30,607	8,801	30,253	19
rip-	72,429	288					2,
ade			97,141	19	739		41
s							
ade							
s							
2,344							
7,773	6,505	7,5	8,872	5,763	5,552	4,2	2,34

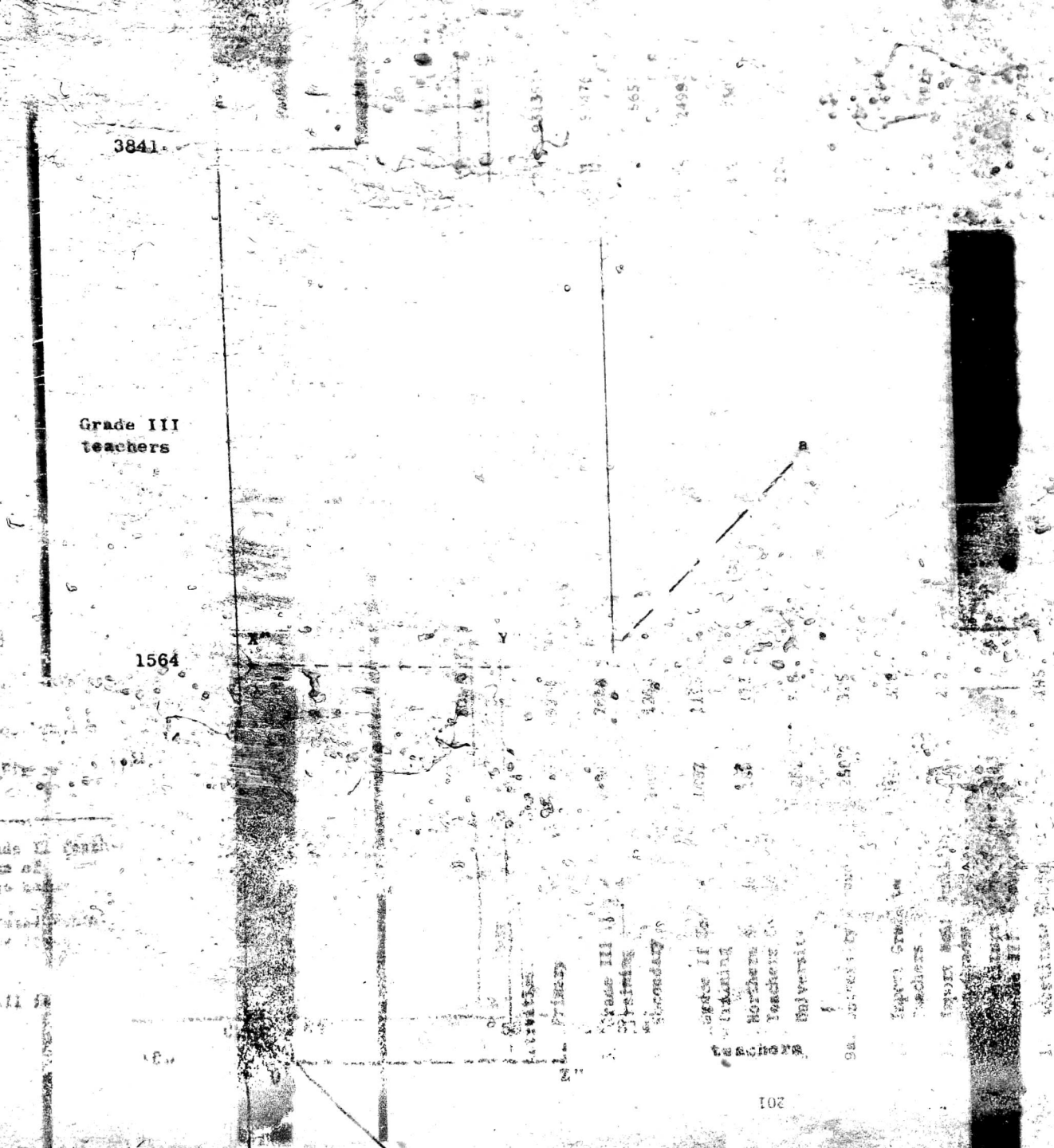
f grade II an

One or more of the substitution activities is used in each time period. The relatively great scarcity of grade III teachers in years 1, 2, and 3 (partly because of the substantial with-drawals from teaching to pursue the grade II course) has made optimal the substitution of equipment for grade III teachers in years 2 and 3 and the substitution of grade II for grade III teachers in year 1. The substitution of grade III for grade II teachers is initiated at fairly low levels in year 2, and increases over the period. The relatively greater scarcity of grade II teachers in the late years can be explained in large degree by the significant increases in the prescribed inputs of grade II teachers in primary schools.

The level of enrollments at the primary level is considerably higher than in comparable solutions (931,353 compared to 728,225 in solution V. Cf. Table 7.4.3 and Figure 7.2.1). Moreover the total levels of admissions to teacher training are only slightly higher than in comparable solutions.[32] Total admissions to grade II and grade III colleges are 24,992 and [illegible] respectively compared to 22,[illegible] in solution V. The ability to [illegible] teacher [illegible] education made possible [illegible]

while in [illegible] VIII redundancy of grade II teachers occurs only once.

The [illegible]s of substitution is depicted in Figure 7.7.1, using year [illegible] illustration.[33] The vertical and horizontal axes define a factor [illegible]s in terms of grade III and grade II teachers respectively. The rays Ox and Oa represent the transformation activity for grade III teachers into grade II's ($X^2_{iii,ii}$) and the production process for primary education. The rectangle OZYX represents the factor availabilities in year 2, namely 3841 grade III and 814 grade II[illegible]ers.[34] From the available quantum of factors must be subtracted the relevant teacher requirements elsewhere in the system, namely the withdrawal of 2627 grade III teachers from primary teaching for entry to the grade II colleges, and the use of 227 grade II teachers both for post primary education and as entrants to the Northern College. The remaining 1214 grade III teachers and 587 grade II teachers are represented by the rectangle OZ'Y'X'. Were substitution possible, production could take place at the with primary school enrolments, admissions in years [illegible]


3841
Grade III
teachers
1564
X
Y
a

By substitution, [illegible] set moves to [illegible], and production takes place [illegible] ments represented by [illegible] were available. [illegible] primary school students is thus possible.

The substitution possibilities have allowed the following endogenous change in the primary education production process in year 2:

Per Student Input of	Original Technology	Defacto Technology
Grade II teachers	.00609	.00522
Grade III teachers	.01217	.01080
[illegible]ditur (£'s per [illegible] [illegible]substit[illegible]	14.4	15.4

[illegible] regarding the use of, and revisions [illegible] addressed to [illegible]

[illegible] HARVARD [illegible] CAMBRIDGE [illegible]

... ed for ... grade ... teach... ... tot... cd

... required ... per grade ...

The shadow ... ces bear the relationship sugges... ...

In the years in which both grade II and grade III teachers are scarce the shadow price of one is equal to the marginal rate of substitution times the shadow price of the other plus or minus the cost associated with the transformation.[40] In year 2, for example, the shadow prices of grade II and grade III teachers are £145,523 and £72,714.[41] The shadow price of grade III teachers is equal to the shadow price associated with the upper bound on the substitution of equipment for grade III teachers plus the present value of the equivalent package of equipment.[42]

The introduction of substituion possibilities has increased the net benefits significantly, from £691,702,593 to £849,341,545, and ... shadow ... of total expenditure is positive in a number of years, ... over the eight year period.

... ersions in education ...

... magnitude ... increase in net benefits g... rated by solution VIII suggests that there are strong economic grounds for exploring and further developing the possibilities for substitution between factors of production in educational processes.

Appendix 7.1. The Sensitivity of the Model to Errors.

At a number of points in this essay the shortcomings of both the data and the assumptions used in the estimation and construction of the model have been pointed out. The degree of confidence which one can place in the solutions of the model depends to a great extent on the sensitivity of the results to alterations in the assumptions or errors in the underlying data.[43] The results of a number of sensitivity tests run on both the objective function and the constraint equations will be presented below.

The objective function is subject to two types of errors:

a. errors in the estimation of the main components of the objective function coefficients such as earnings, wastage rates, and labor force participation rates;

b. errors in the assumptions on which the objective function is based.

Two types of tests have been used to assess the sensitivity of the results to the above type of errors. First, each parameter in the objective function was ranged upwards until a change in the optimal basis occurred, and likewise [illegible]

[illegible] by a variation of the [illegible]

[illegible] from V, grade II teachers are redundant in four

parameters, the optimal basis was not affected by an adjustment up to 1.2 times the original value. In seven cases the optimal solution was affected by an adjustment down to .8 times the value use[illegible] In all but one case the sensitive coefficients relate to universi[illegible] and the effect of the error in the parameter is in gene[illegible] alter the balance between foreign and domestic university study.[45] In the r[illegible] maining case, a downwards adjustment of the value of the net benefits associated with grade III teacher training in year 3 to 83 percen[illegible] of the original value induced a change in the solution.[46]

Alteration of the objective coefficients on an individua[illegible] basis may fail to detect sensitivity to similar errors in all or in a [illegible] group of parameters. For this reason the encouraging results of the sensitivity tests must be supplemented by a second set of tests: computation of solutions with plausible errors assigned to sets of objective function parameters or to the entire objective function. Solutions embodying three sets of changes have been compu[illegible]

a. an objective function based on the assumption that [illegible] percent rather tha[illegible] of the [illegible] 350 grade III teache[illegible] is made pos[illegible]

ence in ed n,

b. a change in the a ned
school leavers from 10 to 20 percent, i dition to the ssumed
post school year of unemployment for all rimary schoo

c. a change in the discount rate from 5 to 10 percent.

Solutions IX, X, and XI respe y, embodying these changes are presented in Tables A7.1.1, A7.1.2, a A7.1.3. Comparison with solutio suggests that with very few exceptions the optimal pattern of enrollm and resource allocation is not significantly affected by the ra substantial alterations in the objective function. The value of the shadow prices and the objective function is, of course, significantly affected.

A possible source of significant error is in the sumption that the benefits associated with any given ctivity are not a
of an

Table A7.1.1

TX: ACTIVITY LEVELS

	4	5	6	7	
	2345	81049	105363	136973	
	8820	6718	6641	7331	
	[illegible]	432	308	211	
	545	611	4162	5376	60
	204	265	344	300	350	400
	96	180	432	558	437	224
	2	549	714	165		
	51	704	865	945	1025	1105
		142	212	212	212	
	) 837,002					

Page 17

28. The present value of the equipment services equivalent to a teacher in year 2 is E285.

A7. 2

TWENTY LEVELS

	5	6	7	
	81049	105365	136975	1[illegible]
887	6718	641	7331	80[illegible]
617	432	302	211	15[illegible]
399	556	4162	5370	[illegible]
285	344	300	320	
180	432	558	437	
549	714	165		
382	293	152		
185	212	212	2[illegible]	1[illegible]

[illegible] (Z*): 533,764,281

Table A7.1.3.

LUTION XI: ACTIVITY LEVELS

	3	4	5	6	7	
100	57330	56873	73935	96115	124950	1624
41	3520	8849	6630	6641	7331	80
7	1650	1155	808	566	396	27
	2013		140	3709	5376	6066
57						
153	199	259	337	300	350	400
378	396	180	432	558	576	360
325	422	549	714	928	393	234
194	385	444	396	225		
40	26	112	212	212	212	212

TIC (Z*): 89,512,572

education increases there will be a tendency for its marginal productivity to fall. The activities for which a substantial expansion is indicated by the solutions and for which this problem is more likely to be serious ar[illegible] primary and university education. It is perhaps worth pointing out that the net additions to the stock of labor with primary and univers[illegible] education are of the same general magnitude as the very crudely estimated rightwards shift in the demand curve for these types of labor. A comparison of the net additions to stock with the estimated movement of the demand curve is presented in Table A7.1.4. If we assume for the s[illegible]e of illustration that the elasticity of demand for both types of labor is .5, the change in the stock of labor will lower the marginal productivity of primary school leavers by 12 percent and raise that of university graduates by 20 percent.[48]

The effect of decline in the primary school leavers' earnings stream of 12 percent is illustrated in solution X (Table A7.1.2).[49] The effects of a 20 percent increase in the earnings stream for university graduates (both those educa[illegible] abroad, and at home) h[illegible]

[illegible] with [illegible] of three of the 69 objective [illegible]

TABLE A7.1.4.

Estimated Shifts in the Demand Curve and Total Output in Solution V for Two Types of Labor

		Primary	University
		t = 1976	t = 1975
1. Estimated "demand in year t[a] (adjusted for retirement)	(D_2)	1,052,982	7613
2. a. Present stock	(D_1)	287,700	2300
b. Present "demand"	(S_1)		
3. Additions to stock resulting from the enrollments suggested by solution V[b] (corrected for wastage)		472,000	4167
4. Additions to stock resulting from the enrollment of students prior to p=1[b]		359,800	400
5. Total stock in year t (S_2) S_2 = (2) + (3) + (4)		1,119,500	6866
Percentage change in S/D: $S_2/D_2 - S_1/D_1$			

...are ide...

A further possibility is that ... secondary school leavers would result in their becoming ... more scarce and experiencing an increasing marginal product. ... ever, the results of the sensitivity tests on the individual coefficients indicate that the optimal basis would not be effected by a change in the secondary school objective function coefficients even if the new value exceeded five times the present value.

In conclusion, the sensitivity tests on the objective function indicate that with minor exceptions, the ... not sensitive to a considerable degree of error in ... the assumed linearity of the ... ratio ... to significantly distort the results.

... constraint ... have been ...

of the constraint vector is objec[illegible] that involved in the objective function, and

b. the value of many of the constraint vector coeffic[illegible] to a large extent arbitrary. The values at which many of the parem[illegible] are set represent conscious policy choices, and consequently sensitivity to changes in the constraint vector can be interpreted in most cases as sensitivity to policy changes rather than sensitivity to error.[1] This reinforces the suggestion made in section 7.2, that in the operation of the model attention should be given to testing the implications of policy changes designed to alter the availability of resources to the system.

Because of the particularly arbitrary nature of the terminal [illegible] have been computed [illegible]

[illegible]

[1] School food and other variables over which the [illegible] exercises some choice.

Table A7.1.6.
XIII: ACTIVITY LEVELS

3	4	5	6	7
57330	67853	88209	114672	80270
499	6604	7421	5313	5865
882	617	432	302	211
1098	1138		1607	43011
642				
98	127	165	215	240	280	320
78	396	180	432	558	472	264
25	422	549	714	195		
78	103	191	174	8		
			147	212	206	

ON (Z*): 612,981,641

Table A7.1.7

SOLUTION XIV: ACTIVITY LEVELS

2	3	4	5	6	7	8
00	44100	56303	39412	51235	66606	69818	48873
			5932	10772	7969	879	9025
800	1150	882	617	432	302	211	148
1846	796	715	10			6451	7275
513	615	642					
138	1[illegible]	217	283	368	360	420	480
252	378	396	180	432	558	402	184
250	375	422	549	714	135		
66		86	154	220	111		
4				114	111	212	212

THE SOLUTION (Z) = 1,085,739

Set Year 1

cantly different from solution V with respect to the later years of the period. However, the first year activity levels are virtually identical with those of solution V except for the Northern Secondary Teachers College and the importing activities.[52] With the exception of grade II and grade III teacher training, the activity levels for years 2 and 3 bear a very close resemblance to those of solution V.

While the considerations underlying the boundary conditions 7.1.4a and 7.1.4b are a fundamental aspect of the educational policy making context, the precise values chosen are arbitrary. Removal of these conditions allows the computation of a solution embodying no explicit non-economic limits on the activity levels relating to the production processes.[53] The outcome of a run in which no boundary conditions are imposed is described in solution AV (Table A7.1.8).[54] The main characteristics of the solution are as follows.

a. The removal of the lower bound on primary school admissions has reduced admission in year 1 to zero. The entire body of grade III teachers in the system (2040) are withdrawn from teaching in year 1 and [illegible] two year course to convert them to grade II teachers [illegible] admission [illegible]

Table A7.1.8

ACTIVITY LEVELS

3	4	5	6	7	8
20935	14924	88473	208100	307214	243780
100					
1501	4495	2926	4476		
		151			
96	180				
	1184				
260	141				
173	120	98	61	84	

967,869,506

...fter ...ar 4. The high shadow price o... senio... ...r-
...sity teachers and of expenditure (in year 3 of 25) combine to limit uni-
versity admissions in years 1, 2, and 3. In year 4, however, 1184
university students are sent abroad.

d. The total net benefits generated by this solution is
£967,869,506 or £276,166,913 higher than the analogous bounded solution
(V). The difference in net benefits is an indication of the substan-
tial opportunity cost of the ... and politi-
tions which gave rise to ... conditions.

Year	1	2	3	4	5
Activities:					
1. Primary					
3. Grade III teacher training					
Secondary					
Grade II teacher training					
Technical training					
Cadets					
Northern primary teachers / aides					
... price					
Export graduate teachers					
Net Migration Non-graduate					
BENEFITS (bounded)					

...ssertion [illegible] the input coefficients ...

...arison of ... in Al ... is to considerably less ... than ...

... The present educational ...

Nigeria are based on the manpower requirements study of the Ashby Commission Report and are set down in a number of other documents (cf. footnote 10 in Chapter 4). The admissions targets based on the present government plans are presented in Table A7.2.1.

A comparison of the enrollment figures in the Table A7.2.1 with those described in Chapter 7 suggests that the use of the planning model described in this essay would yield a pattern of educational development which differs significantly from that based on the manpower requirements assumptions used in [illegible]

... development pro...

... training ... the ... teachers ...

... [illegible] ... [illegible] ... [illegible] ...

... [illegible] ... [illegible] ...

... for example, the number of teachers available ... each period depends on the rate of recruitment of teachers within the system, which is to a large extent dependent on salary structures and other policy instruments, and on the rate of wastage among those students admitted to the system at the beginning of the plan period, which is dependent on the level of school fees and other variables over which the Ministry of Education exercises ... choice.

LE 17.2.1.[a]

MISSIONS TARGETS

3	4	5	6	7
8000 (3000)	101000 (126000)	103000 (128000)	106000 (131000)	108000 (13500
2800 (4200)	3000 (4400)	3000 (4400)	3000 (4400)	3000 (4400
4500 (5000)	5700 (6200)	6900 (7400)	8100 (8600)	9300 (9800)	1 (1100
2070 (1800)	2180 (1910)	2770 (2500)	2770 (2500)	2770 (2500)	277
(280)	(320)	(360)	(400)	(440)	
(128)	(148)	(173)	(195)		
(200)	(200)	(75)	(50)	(25)	

[a] ...issions targets based on the planning exercise ... tual 1964 admissions were considerably below the ...rget ...have been adjusted to reflect an identical patter... of ... equal to the 1964 actual admission. These figures ... ...xt I have used the adjusted figures except in the ... ...ignificantly different from the actual figures. ... ...ission targets for domestic university study. See text.

...most enrollments are higher than those suggested by the targets in Table A7.2.1. Moreover, even in Solution I (using a 7-year primary school course) the pattern of growth in the last years suggests that a longer planning period would yield a very much higher figure for primary school admissions in the early 1970's.

Second, secondary school enrollments suggested by all solutions to the model are considerably below those prescribed in the present government plans, which call for a large admission to secondary schools in 1964 and a rapid rate of growth throughout the planning period. With the exception of Solution XI (employing a 10 percent discount rate) the secondary school activity operates at its lower bound throughout most of the planning period.

Third, the low level of admissions to technical training school contrasts sharply with present plans to enlarge the existing facilities and double number of schools.

Fourth, with the exception of Solution IV, university admissions are considerably below the targets in present plans.[56] According to ... enrollments at Ahmadu Bello University is to ...

1964-67

Most of the solutions of the model suggest [illegible] lower enrolments at Ahmadu Bello University and considerably higher enrollments abroad.[58] Solutions II-VIII, embodying the decision to accept secondary school leavers for university admissions, give considerably higher enrollments in Ahmadu Bello University. However, they are still considerably below those specified by the National Universities Comission Report. Only in solution IV, where the constraint on the recruitment of senior university teachers is relaxed, does the enrollment at Ahmadu Bello University reach substantial proportions.

The operation of the model has drawn attention to the possibility that significant increases in net benefits can be affected through the following changes in the production process:

a. a shortening of the primary school course;

b. admission to university after secondary school rather than after form VI;

c. a number of changes in the structure of inputs involving substitution between different types of teachers and between equipment and teachers.

While these changes are [illegible]

A number of [illegible] been developed here.[1] In particular, no attempt has [illegible] the present model to planning methods used in the rest of the [illegible]

One possible set of applications would involve operating the system without the objective function as a specified model. Where L is a vector of deliveries of various types of labor to the labor force at various dates,[2] and where A and x are the matrix of a_{ij}^t's and a vector of activity levels (as defined in section 3.4) we can write:[3]

8.1.1. $-Ax=L$

or $x=L(-A)^{-1}$

The el[illegible] the inverse of the A ma[illegible] and indirect use of [illegible] resources [illegible]

[illegible]

... results of ... school ...

... sectors

... the capital ... economy ...

linked to the economy by inputs of educated ... the economy and the inputs of educational plant and equipment in the educational system. In addition, all sectors would compete for the use of scarce resources such as high level manpower, savings and foreign exchange.

In the remaining paragraphs, I will attempt an evaluation of the ... and of the particular ... presented above. The various ... arising from ... a linear objective function ... based ... marginal productivity and ... number of ... approach ... sections of ... serious ... rates of growth in enrollments ... (cf. ... relations ...

... it should be noted that the ... in Chapter 2 ... planning process which included consideration of the non-economic aspects of the problem. Those presented in this chapter represent the final results of a planning process which incorporated a large variety of non-economic considerations.

... Unless drastic reductions in the teacher-student ratios are contemplated, the pattern of primary school admissions appears to be inconsistent with the planned output of the teacher training activities.

... ations of the data used. Further information ... concerning the time profile of earnings and labor force participation

imitations, the

First, by

the educa system allows the estimation of the direct and in-
direct effects of a multiplicity of concrete policy choices. The model
facilitates the simultaneous consideration of the efficiency of the ed-
ucational production processes and the optimal levels of production.

Second, the shadow prices generated by the model are particularly
useful in identifying major resource bottlenecks and in suggesting the
relative importance of policy measures to alter educational technologies or
the structure of the educational system.

economic aggregates.

[illegible] the micro-
economic data required by the model was readily available; the labor
market information was generated through the use of a very inexpensive
sample survey. Perhaps more important is the fact that the sensitivity
of the model to errors in estimation and construction does not appear
to be particularly great. (Cf. Appendix [illegible].)

considerably

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...mulation ... ranking as a piece of economic analysis which can contribute to the rationality of a decision-making process encompassing a variety of concrete economic and ... considerations.

This ... application of the model presented in this essay is subject to a number of weaknesses which arise primarily from the limitations of the data used. Further information is particularly needed concerning the time profile of earnings and labor force participation

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which has [illegible] contributed to [illegible] reliance on micro-economic information, while necessitating the [illegible] some stringent assumptions, has allowed the operation of the [illegible]

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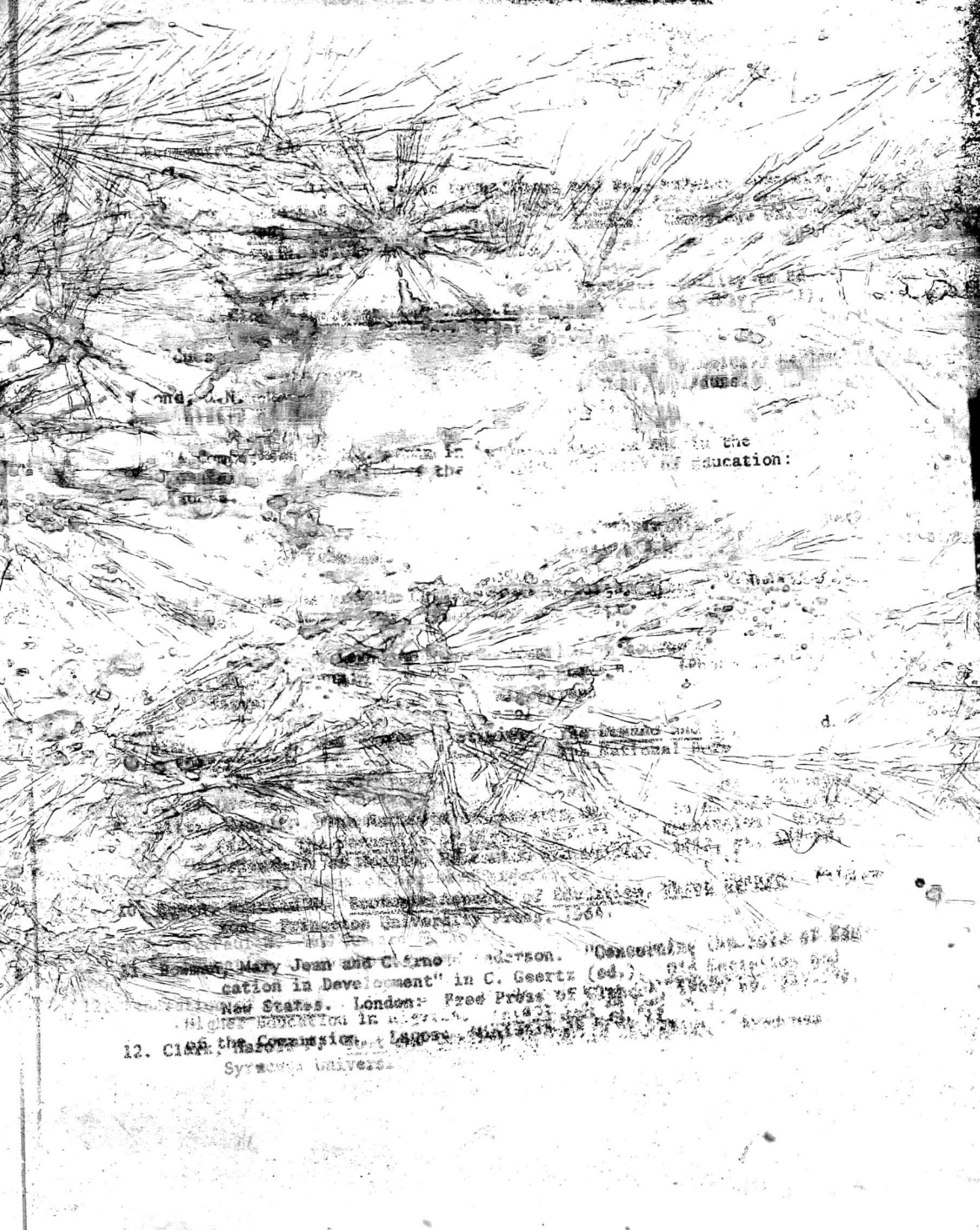

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