DOCUMENT RESUME

ED 100 279 HE 006 182

AUTHOR Nollen, Stanley D.
TITLE The Supply and Demand for College Educated Labor.
PUB DATE Dec 74
NOTE 221p.; Ph.D. Dissertation, University of Chicago

EDRS PRICE MF-$0.75 HC-$10.20 PLUS POSTAGE
DESCRIPTORS *College Graduates; Educational Benefits; Females; *Higher Education; *Human Capital; *Labor Market; Labor Supply; Males; Manpower Needs; Wages

ABSTRACT

In this study a model for the supply of college educated labor is developed from human capital theory. A demand model is added, derived from neoclassical production function theory. Empirical estimates are made for white males and white females, using cross-sectional data on states of the U.S., 1960-70. In human capital theory, education is an investment in future income streams. Measurements have been made of the monetary rate of return associated with college education. In this study the human capital model is extended by testing the investment theory of education as an ex ante behavioral theory. The results for white males support the investment theory of education. An increase in the benefit from college education increases the subsequent stock of college educated white males, and increase in the cost decreases it. Unlike males, the supply of college educated white females is not responsive to changes in their market benefit from college education. However, the male market benefit was a significant female supply determinant. (MJM)

THE UNIVERSITY OF CHICAGO

THE SUPPLY AND DEMAND FOR COLLEGE EDUCATED LABOR

A DISSERTATION SUBMITTED TO
THE FACULTY OF THE GRADUATE SCHOOL OF BUSINESS
IN CANDIDACY FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

BY
STANLEY D. NOLLEN

CHICAGO, ILLINOIS
DECEMBER, 1974

ACKNOWLEDGEMENTS

This research benefitted from the numerous intellectual contributions of Professor B. Peter Pashigian in the Graduate School of Business and Professor Mary Jean Bowman of the Graduate School of Education and the Department of Economics. Valuable assistance was also given by Professors Robert Flanagan, John F. Burton, Jr., and Lee Benham, and especially by Arnold Zellner, H.G.B. Alexander Professor of Economics, all in the Graduate School of Business. Early assistance was given by Professor Richard Freeman of the Department of Economics. Financial support was provided by the Graduate School of Business. I am indebted to the University of Chicago for excellent library and computing facilities. Personal as well as financial support was provided by Nancy Wilson Nollen.

TABLE OF CONTENTS

LIST OF TABLES

Table | Page

LIST OF FIGURES

ABSTRACT

In this study a model for the supply of college educated labor is developed from human capital theory. A demand model is added, derived from neoclassical production function theory. Empirical estimates are made for white males and white females, using cross-sectional data on states of the U. S., 1960-1970.

In human capital theory, education is an investment in future income streams. Measurements have been made of the monetary rate of return associated with college education. In this study the human capital model is extended by testing the investment theory of education as an <u>ex ante</u> behavioral theory. The hypothesis is that the private market benefit from college education has a positive effect on the future supply of college educated male workers, and that the private cost of college has a negative effect. The market benefit is the discounted difference in the earnings of college vs. high school educated workers over the employment lifetime. The cost is direct costs such as tuition and fees, and earnings foregone while a student.

Other supply determinants are the stock of high school graduates available to go to college, and family income and government loans, which represent the ability to

pay for college. Family income also reflects the consumption demand for education.

Alternative hypotheses are developed about how prospective students make a current determination of the benefit from college received in the future. The effect of interstate migration of college educated workers on the benefit they receive is introduced.

Since some working women spend several years of their life out of the labor force, the investment theory of education is less applicable to them. Rather, some females may go to college to obtain a household return such as increased family income.

The demand equation for college educated labor was derived from an aggregate production function. The demand equation includes the wage rate of college educated workers, the prices of related factors of production (high school educated workers and physical capital), and the industrial composition of output.

The results for white males support the investment theory of education. An increase in the benefit from college education increases the subsequent stock of young college educated white males, and an increase in the cost decreases it. The supply elasticity with respect to the benefit is .3; with respect to the cost it is -.7. The implied supply elasticity with respect to the earnings of college educated workers is 1.3. The effect of family income on college-going is positive but the income elasticity is less than one. The existence of geographic mobility of workers does not materially affect these results.

Unlike males, the supply of college educated white females is not responsive to changes in their market benefit from college education. However, the male market benefit was a significant female supply determinant.

The demand for college educated white males age 25-34 was wage-elastic, about -1.5. Both the wages of high school educated workers and the industrial composition of output had strong positive effects on the demand for college educated men.

The supply model was used to predict the 1970 supply of college educated males from 1960 economic data. It made an error of only 3.7 percent while the best U. S. Bureau of the Census projection made an error of 10.5 percent.

This research suggests that the supply of college educated white males has increased rapidly because the market benefit from college education has increased faster than the cost, and because young men are responsive to the benefit and cost. At the same time the relative earnings of college compared to high school educated men have not declined because their demand is wage elastic, the earnings of high school educated substitutes have increased, and changes in the industry mix have increased the demand for college educated workers.

CHAPTER I

INTRODUCTION

In this study a model for the supply of college educated labor is developed from human capital theory. A theory for the demand for college educated labor is added, derived from the neoclassical theory of the firm. Empirical estimates of the parameters of the supply and demand equations are made. White males and white females are studied.

This work is undertaken for three reasons. First, it constitutes a contribution to human capital theory. It does so by using human capital theory to explain the stock of college educated workers in the labor force. Second, this study offers an explanation of why the quantity of college educated labor in the U. S. has increased greatly over time, while the wages of college educated labor relative to high school educated labor have not declined. Third, the results of this study give guidelines for public policy for college educated manpower. They do so by quantifying the effect which various supply determinants have on the future stock of college graduates, and by learning the structure of demand for them. This permits some judgments on how much policy is needed, what approach it should take, and which variables are effective in influencing the supply and demand for college educated labor.

A Test of Human Capital Theory

In human capital theory, education is regarded as an investment in future income streams. The theory says that individuals will invest in a college education if the expected stream of lifetime income benefits, appropriately discounted, exceeds the present cost of the investment. Considerable empirical work has been done on assessing the monetary rates of return associated with investment in college education. From the earliest of these estimates (Becker 1960), to the latest (Hines, Tweeten, and Redfern 1970), the indications are that the private rate of return to college education marginal to high school education is favorable and fairly stable over time for white males in the U. S. (See Appendix II for a summary.)

While the previous rate of return work establishes the *ex post* investment value of college education, it does not allow conclusions about the strength of the investment motivation as a factor influencing the *ex ante* college education investment decision. In this sense, the viability of the investment theory of education *as a behavioral proposition* has not been tested. To what extent does the net monetary return to a college education determine the stock of college educated workers supplied to the labor force? An analysis which deals with this question constitutes a direct test of the predictions of human capital theory about the educational behavior of individuals. Such tests in a labor market context are currently few in number.[1]

An Explanation of Changes in the Number and Income of College Graduates

In the U. S. there have been large increases over time in the number of college graduates, especially in the last two decades. From 1950 to 1970 the number of college educated white males age 25 years or more nearly doubled, from 7.6 percent to 14.7 percent of their total. And the share of white males age 25-34 years with 16 or more years of school completed more than doubled, from 9.8 to 20.9 percent. Yet the absolute real income of college graduates has not shown a general secular decline, nor has their income relative to high school graduates.[2] The figure below shows the trend over time in relative incomes. Despite some year to year variation, the income position of college relative to high school educated young men was better in 1970 than it was in 1949. But there was a downturn in 1971 and 1972, especially for those men age 25-34. While this may foretell a fundamental change, it has a precedent in 1961-63.

This observation has not been fully explained. Can the improvement in the income position of college graduates

---

[1]Freeman (1971) and Johnson (1970) are the relevant ones of which I am aware.

[2]The main finding of Miller (1960) was that the relative income position of highly educated workers did not change from 1946 to 1958.

be accounted for by outward shifts in the demand for them? Are measured wage elasticities of demand and supply consistent with the observed changes in the number and income of college educated workers? The application of the supply-demand model of this paper to these labor market events constitutes a test of the validity of the model.

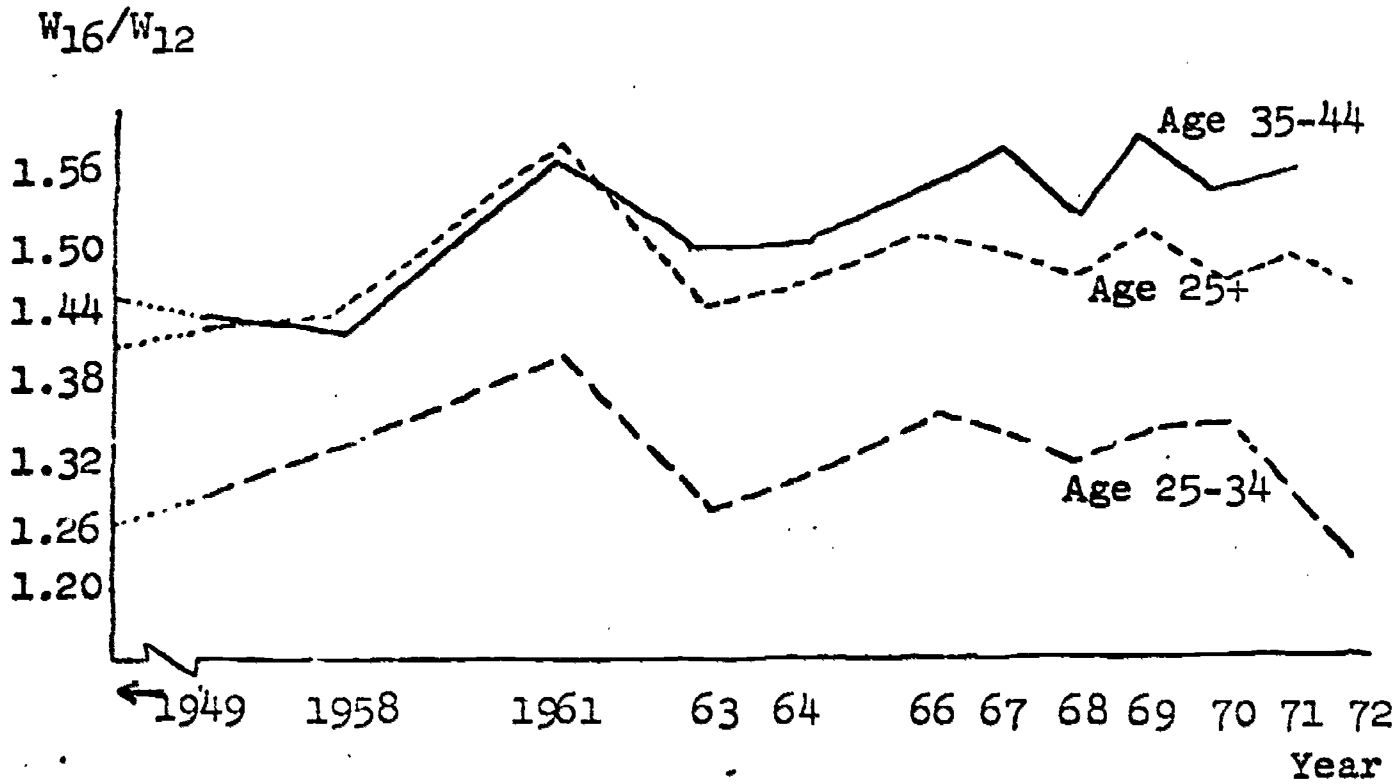

Figure 1.--Ratio of the mean annual income of males with 16 compared to 12 years of school completed (W_{16}/W_{12}), 1949-72

SOURCE: Table 1, p. 19.

Manpower Policy Guidelines

The findings of this study are useful for public manpower policy. In this country, principal objectives of manpower policy have been to minimize shortages and surpluses of workers of all skill and experience levels, to facilitate adjustment to labor market disequilibrium, and to enhance efficiency in production. There is a wide range of policy approaches to implement these objectives. On the one hand, manpower policies may attempt to make labor markets work better (e.g., by improving information flows or by aiding inter-market mobility[1]). In the case of college education, the variables which students use to make decisions can be changed. For example, financial incentives can be altered (by means of selective scholarship aid, tuition subsidies, or government employment). On the other hand, manpower policies may directly intervene into the operation of labor markets.[2]

Guidance for manpower policy for college educated labor is particularly important now. The Bureau of the Census, the Bureau of Labor Statistics, and the Manpower Office of the President have recently issued predictions of an impending surplus of college graduates. But the Carnegie Commission on Higher Education has recommended that universities not establish quotas on admissions. There is public interest in the problem, and policies of one sort or another will be formulated.

This research is undertaken in the belief that public policy for college educated manpower would be improved by a

[1]Guidance and counseling services for prospective college students are one example of improving information flows.

[2]Examples are programs such as manpower retraining or affirmative action hiring quotas.

knowledge of basic parameters of that labor market. How responsive is the supply of college educated labor to changes in the economic benefits and costs of college education? If an oversupply of college graduates and a decline in the economic return to a college education are predicted, a policy of communicating these predictions to new high school graduates will not work unless prospective college students are responsive to changes in the benefits and costs of college. Public policy can affect either the costs or the benefits; it is important to know if policy in one area is more effective than in the other. On most of these questions there is scant evidence; only on the question of the response of college enrollment to changes in tuition is there evidence from more than one source.

The demand side of the market for college educated labor needs to be considered as well. Does the quantity demanded of college educated workers respond to changes in their wages? If the quantity of such workers demanded increases substantially when their wages fall, and if also the stock of college educated workers supplied to the labor market decreases when their wages fall, there would be little need for any manpower policy, beyond one of the facilitating information flows. In the above example, the labor market "works" in the sense that only small wage declines are needed to reduce a potential oversupply of the stock of workers. Unemployment would be minimal since there are large increases in the quantity demanded when wages fall by a small amount. If these basic characteristics of the college educated labor market do not hold, then different manpower policies may be required. In other words, both the general kind of public policy for college educated labor, as well as how much policy is needed, ought to be influenced by the basic characteristics of the labor market. Such knowledge is not currently in hand.

Of course, estimates of some parameters of the supply and demand functions for an aggregate college educated labor factor will not by themselves dictate the design of specific manpower programs. To do this, studies for particular educational specialties, professions, industries, and geographic regions are needed, and information on dynamic disequilibrium adjustment processes is needed (see Freeman 1971). This study contributes one of the essential pieces of knowledge.

The plan of the study is as follows. A model for the supply of college educated labor, based on human capital theory, is developed in Chapter II. A variant of this model for females is worked out in Chapter III. The demand for college educated labor is derived in Chapter IV. The empirical estimation of the supply models is presented in Chapters V and VI, and the demand model is estimated in Chapter VII. In Chapter VIII there is an application of the supply model to the prediction of the future stock of college graduates. A summary of the work is provided in Chapter IX.

CHAPTER II

THE SUPPLY OF EDUCATED LABOR: A HUMAN CAPITAL APPROACH

The Basic Model

The supply of workers at education level i in period t_o, L_{it_o}, is given by the previous period's supply of such workers, L_{i,t_o-1}, the number of entrants into the category L_i in period t_o, $L^e_{it_o}$, and the number who depart from the category L_i in period t_o, $L^d_{it_o}$,

$$L_{it_o} = L_{i,t_o-1} + L^e_{it_o} - L^d_{it_o} \qquad (1)$$

By continuing to write down equations for successively earlier time periods, the supply of educated labor can be built up and expressed generally as the supply at some point in the past plus the number of entrants minus the number of leavers over the time span from that point in the past up to the present time:

$$L_{i,t_o-1} = L_{i,t_o-2} + L^e_{i,t_o-1} - L^d_{i,t_o-1}$$

$$L_{i,t_o-2} = L_{i,t_o-3} + L^e_{i,t_o-2} - L^d_{i,t_o-2} \qquad (2)$$

$$L_{i,t_o-n} = L_{i,t_o-n-1} + L^e_{i,t_o-n} - L^d_{i,t_o-n} \quad ,$$

and where by substitution,

$$L_{it_o} = L_{i,t_o-2} + L^e_{i,t_o-1} - L^d_{i,t_o-1} + L^e_{it_o} - L^d_{it_o}$$

$$= L_{i,t_o-3} + L^e_{i,t_o-2} - L^d_{i,t_o-2} + L^e_{i,t_o-1} - L^d_{i,t_o-1} + L^e_{it_o} - L^d_{it_o}$$

$$= L_{i,t_o-n} + \sum_{t=t_o-n+1}^{t_o} L^e_{it} - \sum_{t=t_o-n+1}^{t_o} L^d_{it} \qquad (3)$$

The objective of the analysis is to explain the stock of educated labor L_i supplied at time point t_o. To do so thus requires an explanation of the number of entrants into and leavers from education level i over time. Even if L^e_{it} and L^d_{it} are not observed quantities in the data, it is possible to proceed if L_{it} is an observed quantity since equation (2) can be rearranged,

$$L_{it_o} - L_{i,t_o-n} = \sum_{t=t_o-n+1}^{t_o} L^e_{it} - \sum_{t=t_o-n+1}^{t_o} L^d_{it} \qquad (4)$$

Therefore a supply equation may be written where the dependent variable is the change in L_i from time period t_o-n to time period t_o, and where the explanatory variables are the determinants of the number of entrants into and leavers from educated labor category L_i over the time span t_o-n+1 to t_o. In this formulation, the equation is actually a supply difference equation. The estimates of the coefficients of the explanatory variables are estimates of their respective effects on the change in the stock of educated labor supplied over time.[1]

The next task is to specify the factors affecting the number of entrants into educated labor category L_i and the number of leavers who depart from that category in any time span t_o-n+1 to t_o. Assume first that there is no mobility of workers between labor markets. This assumption is reasonable if U. S. time-series data are used because the labor market is the entire U. S. at different points in time. Movements of workers between the U. S. and other countries after the completion of formal education are relatively small. However, this may not be a reasonable assumption if U. S. cross-sectional (e.g., state) data are used, so the assumption of no inter-market mobility of workers will be relaxed later.

---

[1]There is a special case of equation (4) when n is large and when $\sum_{t=t_o-n+1}^{t_o} L_{it}^e \gg \sum_{t=t_o-n+1}^{t_o} L_{it}^d$. In this case the number of entrants greatly exceeds the number of leavers over a long time span. This means that the current number of workers with education level i depends mainly on the number of entrants over the long time span and not very much on the initial supply or the number of leavers. Then

$$L_{it_o} = \sum_{t=t_o-n+1}^{t_o} L_{it}^e \quad .$$

In this case the supply relation may be written with L_{it_o} as the dependent variable and with the determinants of the number of entrants into educated labor category L_i as the explanatory variables. (This case might apply to college educated labor if the initial stock were small and there has been a high rate of growth in the stock for many years.)

The Economic Benefits and Costs of Education

The number of entrants into educated labor category L_i in time period t depends in the first place on the number of people who are eligible to undertake that education. The eligible students are the stock of graduates from the next lower education level, j, at time period t-m, where m is the number of years required to go from j to i years of school completed, $j < i$. For example, college students are drawn from the stock of high school graduates, and it usually takes four years to complete college after high school graduation. So the stock of college educated labor at any time point t, L_{it}, is constrained by the prior eligible population of high school graduates, $L_{j,t-m}$. Since most college students enroll soon after high school graduation, L_j refers to high school graduates age 18.

But the interesting behavioral question is what determines L_{it}, given $L_{j,t-m}$. When the education level in question is college education, then a supply function for college educated labor can be specified in part from human capital theory. That theory says that individuals regard education as an investment in the acquisition of productive skills. Education is undertaken because the incremental discounted lifetime earnings stream associated with incremental years of schooling is expected to yield a return to the student's investment in schooling greater than the return available on alternative investments. Therefore the stock of educated labor supplied is positively related to the private net return to investing in schooling. More exactly, the number of entrants into educated labor category i, where i denotes years of school completed, depends on the difference in earnings between workers with i years of school completed and workers with j years of school completed, $j < i$, discounted over the lifetime. This is the economic benefit of education. The number of entrants also depends on the private cost of obtaining i years of schooling which is the earnings foregone while attending school plus the direct costs of schooling which are privately borne. These costs are tuition and fees, books, and room and board costs that would otherwise not be incurred.

Because schooling takes a number of years to complete, there is a lag between the point at which an individual decides to invest in education and the point at which he enters the labor force and begins to receive the returns to education. Therefore the number of entrants into the labor force at time t who have i years of school completed, L^e_{it}, depends on benefits and costs of education evaluated by the student at the earlier time point t-m. This is the prospective student's decision point. The relationship may be written for particular time points as

$$L^e_{it_o} = f_o(NR_{i,t_o-m}, A_o)$$

$$\cdots\cdots$$

$$L^e_{i,t_o-1} = f_1(NR_{i,t_o-m-1}, A_1)$$

$$L_{i,t_o-2} = f_2(NR_{i,t_o-m-2}, A_2)$$

$$\vdots \qquad \vdots$$

$$L^e_{i,t_o-n+1} = f_{n+1}(NR_{i,t_o-m-n+1}, A_{n+1}) \tag{5}$$

where NR_{it} = expected private net return to education level i evaluated at time t, and A_t includes L_{jt} as well as a vector of other supply determinants not yet specified.

The private net return to education level i marginal to level j can be expressed in terms of a benefit component and a cost component. It is calculated for decision point t_o-m as:

$$NR_{i,t_o-m} = \sum_{t=m+1}^{k} \frac{W_{it}-W_{jt}}{(1+r)^t} - \sum_{t=1}^{m} \frac{W_{jt}+DC_{it}}{(1+r)^t} \tag{6}$$

where W_{it}, W_{jt} = earnings in year t of workers with i and with j years of school completed

DC_{it} = private direct costs of obtaining i years of schooling in year t

r = the discount rate

k = the employment lifetime

m = the number of years required to go from i to j years of school completed.

The costs of foregone earnings and the direct costs of schooling begin in the decision year t = t_o-m (the year of college enrollment, or year 1 in equation (6)), while the benefit stream W_{it}-W_{jt} begins in the future year t = t_o =

year m+1. The cost and benefit streams are discounted back to the decision year.

It should be noted at this point that earnings foregone due to education may be partially offset by part-time earnings of students while they are in school. The W_{jt} variable in the costs term of equation (6) is intended to represent net for gone earnings. (Of course if a student's part-time job causes his schooling period to be lengthened, then m increases and the total costs incurred for the completion of schooling may not be different from the case of no part-time work.)

How Does the Prospective Student Determine the Return to Education?

According to human capital theory the prospective student behaves as if he knew the earnings difference W_i-W_j for each year of the future. But his determination of the benefit to incremental education can only be an expectation based on his knowledge of past and present earnings differences. There is some evidence that young men do possess considerable information about current W_i and W_j and that they have some awareness about predicted changes in the earnings of college graduates (Freeman 1971). But there is no well-established theory or empirical evidence on how such information is used by the prospective student to form expectations of the benefit to incremental education. In fact a weakness of the human capital model from the standpoint of individual decision theory is that calculated rates of return to education are historical _ex post_ measures, while the decisions made by individuals require _ex ante_ expectations of rates of return. How are these expectations formed? Since the actual return to education depends on earnings received only in the future, what information is used by prospective students to make the college education decision in the present?

It is an empirical fact that the earnings of those with more education increase faster with age and labor force experience than the earnings of those with less education.[1] Because of the increasing spread between the age-earnings profiles of college compared to high school educated workers, it is not likely that prospective college students use starting salaries to determine their expected lifetime benefit from college education. Reckoning starting salaries alone would underestimate the true return to education.

A better hypothesis is that the prospective college student reckons the earnings difference between college and high school educated workers when they are several years, perhaps 8-9 years, out into the labor force.[2] This hypothesis says that prospective college students who made the

---

[1] This is documented in Hanoch (1968). The data come from the U.S. Bureau of the Census, both the decennial _Census of Population_ and the annual _Current Population Reports_.

[2] The choice of 8 or 9 years is suggested by the work of Mincer (1970) in on-the-job training. See the section on experience and on-the-job training beginning on page 31.

education decision in, say, 1960 when they were age 18 used information on the earnings of college and high school educated workers who in 1960 were in the neighborhood of age 30. This benefit hypothesis, using earnings of experienced workers rather than starting salaries, is appropriate empirically because it acknowledges the actual behavior of earnings profiles over time. It is appropriate theoretically because it implies that prospective students seek to evaluate their lifetime economic benefit from incremental education as the human capital model predicts. Therefore this benefit hypothesis is desirable because it permits a test of human capital theory as a behavioral proposition. It permits a test of whether students behave according to the model.

Current vs. predicted earnings. The hypothesis that prospective students use information on the earnings of experienced college and high school educated workers to determine their benefit from education may be formulated in two alternative ways. The simpler way is that of the example above: the current earnings, i.e., earnings in the college education decision year, of workers who in that year are about age 30 are used. This information is available at the time of undertaking additional investment in schooling.

Alternatively the benefit hypothesis may be formulated by assuming that prospective students are not only aware of the behavior of earnings profiles with age, but also that they predict at least one point of the age-earnings profile in the future. According to this hypothesis, the prospective college student who is age 18 in 1960 predicts the earnings of college and high school educated labor in, say, 1970 when he himself is several years out into the labor force and not far from age 30.

Both of these benefit hypotheses assume that prospective students choose one point on the age-earnings profiles to use in calculating their benefit from additional education. That one point is ideally several years after labor force entry because of the increase in the earnings difference between college and high school educated workers with age, and because of the influence of on-the-job training on earnings (see pp. 31-33). The assumption that just one point of the age-earnings profile is used, rather than the entire profile of earnings with age, is in part required by limitations of data, since the data on earnings by educational attainment are not disaggregated by age for all time periods for the unit of analysis used in this study (states of the U. S.). However, the assumption is a reasonable one because an evaluation of many points in the age-earnings profile, including points late in the employment life cycle, imposes high informational demands on the prospective student. In any event, the discounted present value of earnings benefits received far into the future is small, so neglecting them may not be serious.

Both the current earnings and the predicted future earnings benefit hypotheses further assume that prospective students estimate the earnings difference without systematic error; i.e., they neither underestimate nor overestimate $W_i - W_j$, whether now or in the future.[1]

The two hypotheses differ in their assumptions about whether prospective students use current earnings information or make predictions of future earnings to evaluate the benefit from additional education. The latter hypothesis requires greater sophistication on the part of the prospective student. Of course if the difference in earnings by educational attainment does not vary much over time, the hypotheses become indistinguishable. If $W_i - W_j$, although variable, is very highly serially correlated, it may not matter which hypothesis is used since in this case the current earnings difference would be a good predictor of the future earnings difference. Likewise, if the net return to additional education is stable over time then the choice of expectations hypotheses is not important.

In this connection, the behavior of $W_i - W_j$ over time is of interest in its own right. Not only can it illuminate the differences in the benefit hypotheses above, but also it can serve as a rough test of the correspondence of empirical observations with theoretical predictions. For

---

[1]They may systematically err in estimating W_i and W_j as long as they make equal absolute errors for both so that $W_i - W_j$ is unaffected.

example, if W_i-W_j has increased over time, that implies there has either been an increase in the rate of return to college education, or there has been an increase in the costs of a college education to prevent the rate of return from rising. The evidence on the trends in this data is given in Table 1.

TABLE 1.--Mean annual income of males with 16 and 12 years of school completed (W_{16}, W_{12}), current dollars, by age group, 1949-1972, U. S.

Year	Age 25-34		Age 35-44		Age 25+	
	W_{16}	W_{12}	W_{16}	W_{12}	W_{16}	W_{12}
1949[a]	3,550	3,080	5,142	3,523	4,407	3,285
1958	6,302	4,768	8,037	5,665	7,567	6,257
1961	7,467	5,357	10,016	6,411	9,342	5,946
1963	7,300	5,815	10,525	7,122	9,392	6,557
1964	7,844	6,175	10,613	7,162	9,757	6,736
1966	9,252	6,880	12,274	8,040	11,135	7,494
1967	9,652	7,239	13,276	8,460	11,721	7,907
1968	10,121	7,812	13,629	9,185	12,236	8,430
1969	10,777	8,133	15,133	9,592	13,258	8,827
1970	11,133	8,377	15,167	9,868	13,372	9,185
1971	11,036	8,714	15,934	10,279	14,158	9,566
1972	11,553	9,451	17,480	11,312	15,256	10,433

[a]Median annual income.

SOURCES: U.S. Bureau of the Census, Current Population Reports, Series P60, "Consumer Income," Nos. 74, 75, 80, 85, 90; U.S. Bureau of the Census, Census of Population, 1950, Special Reports, v. iv, Part 5, Ch. B, "Education."

The difference, W_{16}-W_{12}, is shown in Figure 2 below, in constant 1967 dollars.

The income advantage enjoyed by college educated workers has generally but irregularly risen. An exception

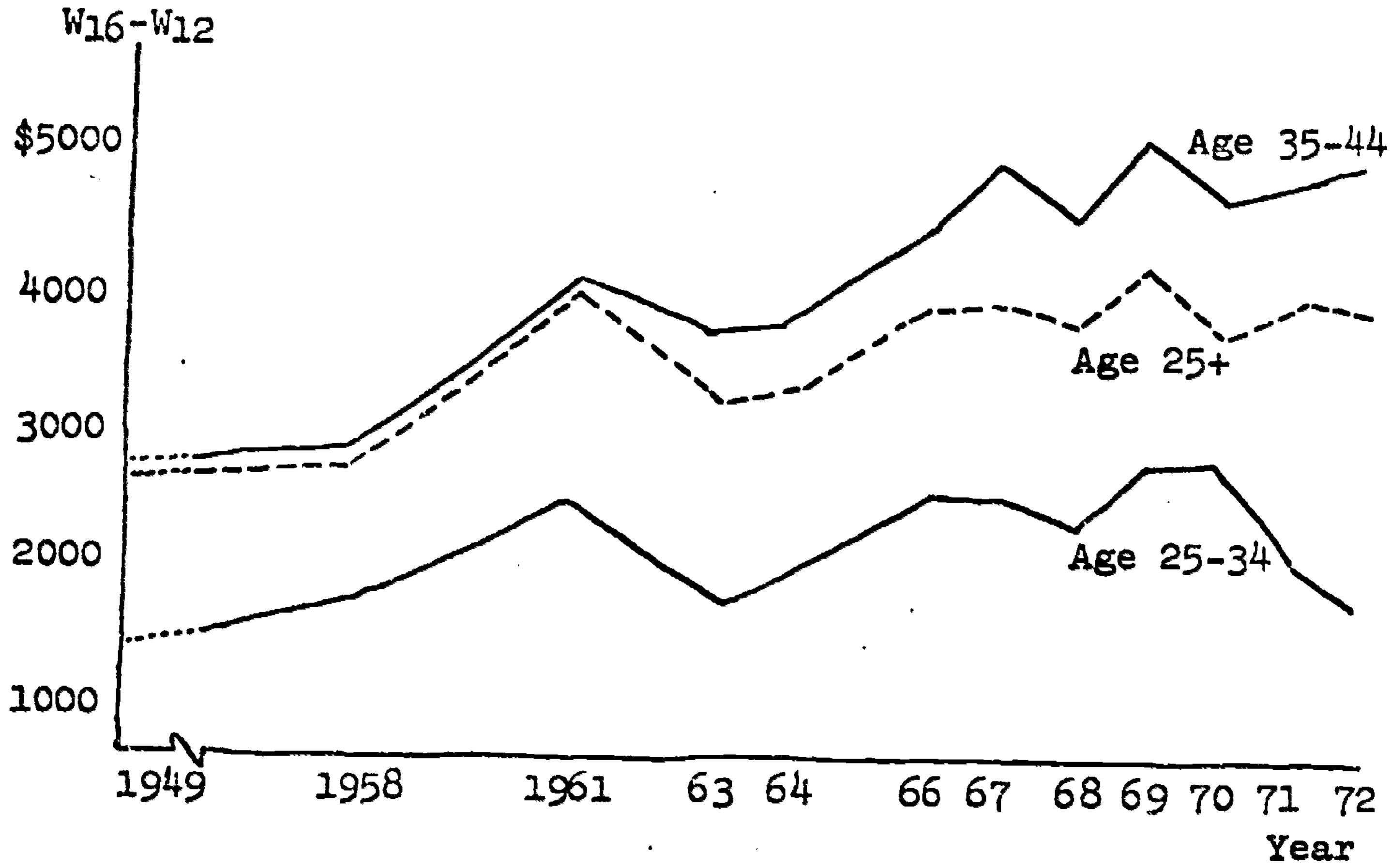

Figure 2.--Difference in the mean annual income of males with 16 and 12 years of school completed (W_{16}-W_{12}), constant 1967 dollars, by age group, 1949-1972, U. S.

SOURCE: Table 1.

to this trend is the decline in W_i-W_j for men age 25-34 in the two successive years 1971 and 1972.[1] The first order serial correlation coefficient of W_i-W_j for men age 25+ is .64. While this correlation is quite high, there remains considerable room for predictions of future W_i-W_j to be

[1]The recent and quite sharp drop in W_i-W_j for young men is likely a reflection of the unfavorable labor market for college graduates that has developed. W_i-W_j for older men has not yet been affected, but continuation of the current labor market situation may foretell the first decline in the rate of return to a college education since such measurements have been made.

superior to current W_i-W_j for purposes of determining the benefit of a college education. The second benefit hypothesis--that students predict future W_i-W_j--should therefore be tested.

As noted above, there has been no discernible trend in the measured rate of return to a college education from 1939 to 1969 (see Appendix II).[1] This suggests that college costs must have increased. In fact this is true (see Table 2).

The total cost of a college education increased more than 2.3 times over the last two decades. This change is similar to the increase in W_{16} and W_{12} over this period, about 2.7 times and 2.6 times respectively. These similar proportional changes are consistent with the relatively stable calculated rates of return over time which have been reported by other authors (Appendix II). They are also consistent with expectations of successfully operating and adjusting market activities, wherein movements away from equilibrium are quickly corrected. This assures that the observed rates of return are equilibrium rates and that the level of the equilibrium rate of return has not changed over time.

In the cross sectional analysis of this study, similar relationships can be tested to assure that the observations are sufficiently close to equilibrium

[1]The evidence in Figure 2 suggests no large changes up to 1969.

TABLE 2.--Costs of a college education for males, 1949-1969, U. S. (current dollars)

Year	Foregone Earnings[a]	Tuition and Fees[b]	Tuition, Fees, Room and Board[b]
1949	1,670	162	336
1959	2,495	295	598
1969	3,695	448	870

[a]Median annual income of high school graduates age 18-24.

[b]Revenues per enrolled student in 4-year institutions of higher education, net of scholarship aid. Years are 1949-50, 1959-60, and 1968-69.

SOURCES: (1) Foregone earnings: U.S. Bureau of the Census, Census of Population, 1950, v. IV, Special Reports, Part 5, Ch. B, "Education"; and Census of Population, 1960 and Census of Population, 1970, Subject Reports, PC(2)-5B, "Educational Attainment." (2) Tuition, fees, room and board: U.S. Office of Education, Biennial Survey of Education in the U.S., 1948-50, Part 4, "Statistics of Higher Education, 1949-50"; USOE, "Financial Statistics of Institutions of Higher Education 1959-60," Circular No. 744, OE 50023-60; USOE, National Center for Educational Statistics, "Financial Statistics of Institutions of Higher Education, Current Funds, Revenues and Expenditures, 1968-69," OE 52010-69; USOE, "Opening (Fall) Enrollment in Institutions of Higher Education, 1960," Circular No. 652, OE 54007-60; USOE, National Center for Educational Statistics, "Fall Enrollment in Higher Education, 1969, Supplementary Information," OE 72-6.

observations to allow the model to work. In long run equilibrium, the dollar value of the net discounted return to college education should be zero. If this is assumed for observations on states of the U. S., is the implied internal rate of return reasonable? According to the solved state internal rates of return, the answer is yes. The average over states for white males is 14.3 percent. This rate of return is slightly above the return obtainable from other investments. (See Appendix III for this information and for further analyses of the behavior over time of internal rates of return by state.) Also, if the net return to a college education is to stay near equilibrium, it should be true that changes across states in the direct costs of college (DC_i) are positively correlated with changes in W_i-W_j. The correlation coefficient between DC_i and W_i-W_j in 1960 for states of the U. S. is .31. Simple empirical tests such as these show that both U. S. time series and cross sectional relationships between the benefits and costs of college are consistent with theoretical expectations. Thus they constitute additional validations of the theory and the data used in this study.

Involuntary drop-outs. Not all of those who enroll in college will graduate and enter the labor force as college educated workers. Some will drop out voluntarily due to a change in their tastes for college education or due to attractive economic opportunities that become available.[1] Some will drop out involuntarily, due to academic failure or financial hardship. Presumably a prospective student has

[1]However, it has been shown that the rate of return to partial college (13-15 years of school completed) marginal to high school, which is 12.1 percent, is smaller than the rate of return to completed college marginal to high school, which is 13.6 percent. Also, the net return to completed college marginal to partial college is high (15.1 percent). These results are from Hines, et al. (1970). Therefore economic reasons for voluntarily dropping out should not be important in general.

some knowledge of the probability that he will not be able to complete college and hence will not get the net return to college education. Therefore the calculated net return term NR_i should be adjusted for the probability that it will be obtained:

$$E(NR_i) = (1-\rho)NR_i + \rho NR_j \qquad (7)$$

where $E(NR_i)$ = the expected value of NR_i

ρ = the involuntary drop out rate

NR_j = the net return to whatever level of schooling has been completed prior to dropping out (j = 12, 13, 14, or 15 years of school completed).

This equation is a shorthand expression for a more complete equation which would include a separate term for the net return to each of the possible educational attainments (12, 13, 14, or 15 years of school completed) multiplied by the probability of reaching that attainment. (The simpler symbol NR_i will continue to be used, but the expected NR_i of equation (7) is understood.)

Those students who flunk out usually do so in the first or at least second year of college. The net return they get to a small amount of college may therefore be close to zero.[1] Even if the rate of return is not zero (it could

[1]Evidence available on the return to partial college (13-15 years of school completed--see footnote on p. 23) includes junior college graduates. In some preliminary work, Freeman suggests that the rate of return to a terminal two-year college education may exceed that of a four-year college education. This means that the rate of return obtained by drop-outs from four-year colleges is less than the calculated rate of return to partial college. A rate of return of zero would seem to be a suitable assumption for college drop-outs.

be negative), the absolute net dollar return would be very small relative to the net return to four or more years of college, if most drop-outs occur after just one year of college attendance. If the net return to some college is zero, then the last term of equation (7) drops out.

The existence of voluntary drop-outs does not affect the expected NR_i term because that decision is not anticipated when the NR_i calculation is being made by the prospective student.

The discount rate. The discount rate, r, in the net return to education term, depends on the rate of return students could get in their next best alternative investment. This is their cost of capital. Capital markets for the financing of education by individuals appear to be imperfect. Thus the borrowing rate as well as the lending rate should be considered in determining the discount rate. The degree of capital market imperfection indicates how high the marginal borrowing rate is. The seriousness of the capital restriction, which is the extent to which education costs are met by private market borrowing, indicates the weight of the borrowing rate in determining the discount rate. Note that investment in education differs from investment in physical capital because borrowing by students in private capital markets to finance education is more expensive, if possible at all. Such capital markets have appeared only recently. For some, the marginal borrowing rate may be infinite. The popularity of government loan programs is probably due to the high cost of private market borrowing. This means that the marginal borrowing rate has little effect on the determination of the discount rate used for education investments, as it normally would, since such borrowing is almost non-existent. As a simplification, the borrowing rate is assumed infinite and constant for all prospective students.[1] Since subsidized loan rates are also constant for all individuals at a point in time, they will not cause any difference in the net return term in a cross-sectional analysis.

The discount rate also depends on the prospective student's subjective rate of time preference for income since investable funds may be used for immediate consumption rather than for investment (Blaug 1971). That is, given the same alternative rate of return, two prospective students may make different education decisions if their rate of time preference for income is different. The calculation of the discount rate thus depends on the lending rate, adjusted for the subjective rate of time preference. Since neither of these components is known with certainty for states of the

[1]Some students may be able to borrow indirectly via loans taken out by their parents. For example the student's parents may mortgage their house to pay for the college education. However, there will be little variance in the level of this indirect borrowing rate among students at a given point in time. The extent to which such family financing is used will be affected by family income and wealth. This influence is considered below.

U. S., several different calculations of the discount rate are used to insure that the regression coefficients obtained are not artifacts of the calculated discount rate. (See Appendix I for a full description of how the discount rate was calculated.)

The Ability to Pay

If private borrowing by students to finance personal investments in education is not possible, then the amount of such investments made will depend not only on the net return to the investment, but also on the potential investor's ability to pay. The private direct costs of education must be met by cash outlays obtained from the current income or wealth of the student or his parents, or from government loans. Individuals from low income families may undertake less college investment than individuals from high income families, despite a favorable net return, because they cannot finance the investment. This means that the equation for the supply of educated labor should contain variables to represent ability to pay. One such indicator is family income of families where the head of household is in the age range where he or she would be likely to have a college-age student. Another ability to pay variable is government loan aid per student.

Education as a Consumption Good

Education may also have some properties of a consumption good, or a consumer durable. Benefits are obtained by college educated workers other than the income gain associated with employment as a college educated worker. The consumption return is a non-labor-market return. It may be non-pecuniary benefits of employment, or psychic satisfactions not connected with the workplace. In addition the process of learning itself may be enjoyable for some. There may be a consumption benefit in the acquisition of education. Education may be unique in that it is simultaneously an investment and a consumption good; i.e., one may undertake education for investment purposes and at the same time derive consumption benefits. This analysis does not try to separate consumption from investment demand. Yet the consumption good properties of education must be considered. To the extent that a consumption demand for education exists, the observed stock of educated labor will be higher than that predicted by the net return to education alone. As with a conventional demand equation for a consumer good, the demand for education as a consumer good would be expected to depend on its price and on an income variable.[1] Therefore the equation for the supply of educated labor should be specified with an income variable, such as the income of the student or his family. Thus a single income variable serves to represent two effects on the stock of educated labor: the ability to pay for education as an investment good, and

[1]Most studies of the demand for college enrollment have included an income variable and found that it had a significant positive coefficient.

the conventional effect of income as a consumer good demand function shifter. Both effects are expected to be positive.[1]

As with the net return variable, the income variable, Y, and the loan variable, LOAN, must be lagged since their effects on the number of entrants into educated labor category L_i operates at the time the schooling decision is made. Thus $L^e_{it_o}$ depends on Y_{t_o-m}; L^e_{i,t_o-1} depends on Y_{t_o-m-1}, ... ; L^e_{i,t_o-n+1} depends on $Y_{t_o-m-n+1}$, and similarly for LOAN.

Empirical Considerations

Several considerations about the empirical specification of the supply equation require discussion.

The empirical specification of the benefit from college. The prospective college student is hypothesized to determine his economic benefit from college education by choosing one point on the age-earnings profile; e.g., the current earnings of experienced college and high school educated workers (see pp. 14-16). A single value for $W_{it}-W_{jt}$ is used to calculate the benefit of college education. Thus the earnings difference becomes a constant over the summation, and the benefit of college education term (BEN_i) is

[1]Both transitory and permanent income would seem relevant. Transitory income might influence the purchase of education as a consumption good giving enjoyment from learning. The permanent income concept might be more relevant for the purchase of education as an investment good. Data limitations do not permit further exploration of the effects of each income concept on the quantity of education purchased.

calculated as

$$BEN_i = \sum_{t=m+1}^{k} \frac{W_{it}-W_{jt}}{(1+r)^t} = (W_i-W_j) \sum_{t=m+1}^{k} \frac{1}{(1+r)^t} \quad (8)$$

since W_i-W_j, without the time subscript, is treated as a constant. Because the lifecycle is long, k is a large number. Thus

$$\sum_{t=m+1}^{k} \frac{1}{(1+r)^t} \doteq \frac{1}{r} - \sum_{t=1}^{m} \frac{1}{(1+r)^t}$$

for large k,[1] and

$$BEN_i \doteq (W_i-W_j) \left[\frac{1}{r} - \sum_{t=1}^{m} \frac{1}{(1+r)^t} \right] \quad (9)$$

Education level i is taken to be college education (i = 16 or more years of school completed), and level j is high school education (12 years of sch^ol completed).

---

[1] The term $\sum_{t=1}^{m} \frac{1}{(1+r)^t}$ is subtracted from $\frac{1}{r}$ because the summation of the benefit stream begins only after the education is completed in year t=m+1, whereas the approximation of using $\frac{1}{r}$ to obtain the discounted present value of the future earnings benefit requires that the benefit begin in year t=1. Note that

$$\sum_{t=m+1}^{k} \frac{1}{(1+r)^t} = \sum_{t=1}^{k} \frac{1}{(1+r)^t} - \sum_{t=1}^{m} \frac{1}{(1+r)^t} .$$

$$\text{As } k \longrightarrow \infty , \quad \sum_{t=1}^{k} \frac{1}{(1+r)^t} \longrightarrow \frac{1}{r}$$

by the result of the summation of an invinite series.

Experience and learning on the job. Observed earnings may reflect not only direct gains from formal schooling but also associated indirect gains from experience and learning on the job. There may be differences across observations in the amount of experience embodied in the stock of college (or high school) educated labor. If so this would be an undesirable source of variation in observed W_i (or W_j) since it reflects not only the future earnings expected by a prospective college student, but also the current age structure of the college (and high school) educated labor force. That is, an observed W_i may be low not because of a large supply or small demand for L_i but simply because the age composition of L_i is young. Data on age by years of school completed can be used to account for these effects on W_i and W_j.

Likewise, college (or high school) educated workers may differ in the amount of on-the-job training they obtain. Investments in on-the-job training in the early years of employment will depress earnings in those years and increase earnings in later years.[1] This means that the time point at which W_i or W_j is measured is critical, assuming the amount of on-the-job training for L_i (or L_j) differs across observations. Mincer has calculated the "overtaking point,"

[1]See Becker (1962) and Mincer (1962, 1970). This result holds unless training is completely firm-specific and there is no sharing of training costs and benefits between firm and worker.

the point in time at which the earnings of those with on-the-job training catch up to those without training, for equal formal schooling. It is about nine years (Mincer 1970). If earnings W_i and W_j are measured after nine years of labor force experience it will not matter if observations differ in the amount of on-the-job training since there is equality of earnings of those with and those without on-the-job training at that point. If, however, W_i and W_j are measured later than that, observations with high on-the-job training for L_i (or L_j) will have high W_i (or W_j), and conversely if W_i and W_j are measured early. Thus the calculated benefit of college education is sensitive to the time of measurement of W_i and W_j.

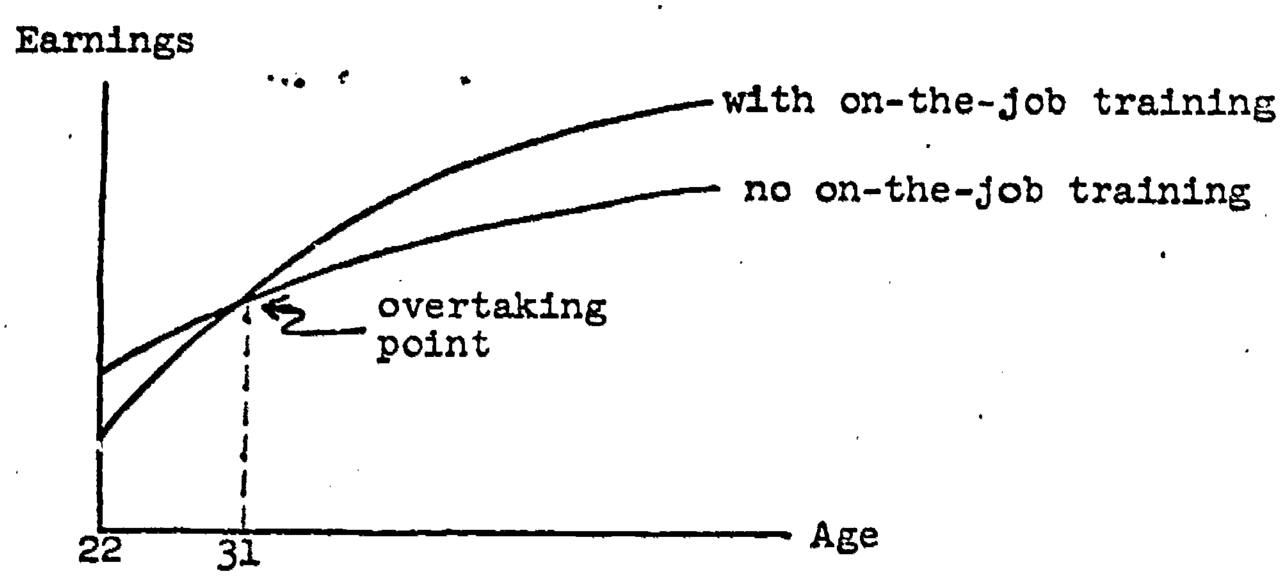

Figure 3.--Illustration of age-earnings profiles for college educated workers with and without on-the-job training

An appropriate measurement time is the overtaking point. This means that W_i should be measured about age 31 and W_j about age 27. But empirically this is not possible when states of the U. S. are the units of analysis because data on earnings by years of school completed are not available by single years of age. Data are available for computing W_i-W_j (as median annual income) for white males age 25+ in 1960. The average state value of this indicator is $2,222. Fortunately this state average value can be compared with the aggregate U. S. value of W_i-W_j, measuring W_i at age 31 and W_j at age 27. This value is about $2,275.[1] Thus, on average, the observed W_i-W_j, using the theoretically less desirable measure, is very close to the preferred measure if it were available by states of the U. S. Consequently, the calculated value of BEN will not be systematically in error, although state variations in on-the-job training remain unaccounted for.

Earnings vs. income. According to the investment theory of education, the indicators for W_i and W_j should measure the monetary returns associated with the investment in formal schooling. This means that labor earnings is preferred to total income to indicate W_i and W_j. Total income could include income from inherited property, which is in

---

[1]Obtained by curvilinear interpolation of W_i and W_j between age groups 25-29 and 30-34. Data by single years of age for the aggregate U. S. is not available. Linear interpolation gave a value of W_i-W_j of $2,175.

no way related to the educational attainment of the present generation. On the other hand, the purchase of education is an investment in less unemployment and more time worked as well as an investment in higher rates of pay, so that the earnings measure should reflect these differences between college and high school educated workers.

Leavers from an educated labor category. In the absence of inter-market mobility of workers, the number of workers who leave a given educated labor category in any time period t depends on the number of retirements and deaths of such workers, and on the number of those workers who reach a higher level of educational attainment. In the case of workers with college education or more, only the former possibilities apply. Although the number of deaths of college educated workers in any period may not have an interesting economic explanation, it may vary from observation to observation depending on how many old members there were in that category in the preceding time period. Define L_{it}^{o} to be the number of workers at education level i who are in the uppermost age group of the labor force at time period t. Then the partial effect of L_{i,t_o-1}^{o} on L_{it_o} should be negative. Likewise there should be negative relationships between L_{i,t_o-2}^{o} and L_{i,t_o-1} and, in general, L_{i,t_o-n-1}^{o} and L_{i,t_o-n}.

<u>Simplifications imposed by the data</u>. The supply equation for educated labor can be written

$$L_{it_o} - L_{i,t_o-n} = S(NR_{i,t_o-m}, NR_{i,t_o-m-1}, \ldots, NR_{i,t_o-m-n+1},$$
$$L_{j,t_o-m}, L_{j,t_o-m-1}, \ldots, L_{j,t_o-m-n+1},$$
$$Y_{t_o-m}, Y_{t_o-m-1}, \ldots, Y_{t_o-m-n+1},$$
$$LOAN_{t_o-m}, LOAN_{t_o-m-1}, \ldots, LOAN_{t_o-m-n+1},$$
$$L^o_{i,t_o-1}, L^o_{i,t_o-2}, \ldots, L^o_{i,t_o-n-1}) \quad (10)$$

where education levels i and j refer to college and high school education, respectively,[1] where the subscript m refers to the duration of schooling (m = 4 years for college education), and where the subscript n refers to the number of time periods over which the change in L_i is measured. (See p. 36 for the meaning of the symbols for the variables.) NR_{it} can be broken down into a benefit component, BEN_{it}, and a cost component, $COST_{it}$.

The supply relation must be simplified because not all the required data are available for all of the n time periods. (For example, U. S. cross-sectional data in some cases are only available for two census years.) If t_o is set at calendar year 1970 and n=10 years, so that t_o-n is calendar calendar year 1960, then the end points of the time

[1]If the equation explains the stock of high school educated labor, an additional set of terms to indicate leavers from that category via the acquisition of a college education must be added.

span for measuring NR_{it}, which are NR_{i,t_o-m} and $NR_{i,t_o-m-n+1}$, correspond to the years 1966 and 1957. The same is true for the other right-hand side variables. Data from the 1960 Census of Population fall in this time span and can be used as the source for a single calculation for NR_{it} and Y_t. Likewise, data from the 1970 Census of Population can be used for a single calculation of BEN_{it} under the alternative hypothesis for how prospective students determine BEN_{it}, which says they predict future (e.g., 1970) earnings profiles. Since neither NR_{it} nor aggregate Y_t fluctuates widely in a short time span, the use of a single indicator for each variable which falls in the relevant time span should be satisfactory compromise.[1]

The simplified supply relation, written with the proposed calendar years of measurement in place of the index t, is

$$L_{i,1970} - L_{i,1960} = S(NR_{i,1960}, L_{j,1960}, Y_{1960}, LOAN_{1960}, L^o_{i,1960}) \quad (11)$$

where $NR_{i,1960}$ = the net return to education level i determined in 1960

$L_{j,1960}$ = the number of people with education level j in 1960 who are eligible to continue to education level i

[1]Evidence in Appendix II shows that the private rate of return to a college education investment has been stable over time.

Y_{1960} = income of families in 1960 who have college age children[1]

$LOAN_{1960}$ = government loans in 1960

$L^{o}_{i,1970}$ = the number of people with education level i who are 55 or more years old in 1960.

If prospective students predict future age-earning profiles to determine the anticipated net return, then 1970 earnings data are used in place of 1960 earnings data in the benefit term of the net return variable and $NR_{i,1960}$ becomes $NR_{i,1970}$. If the two hypotheses about the determination of the benefit (the use of current vs. the prediction of future wage differences) are combined, then a weighted average benefit and net return variable result. Since there is no theoretical basis by which to determine the weights, they may be determined by the data. Writing $L_{i,1970} - L_{i,1960} = a + bwNR_{i,1960} + (1-w)NR_{i,1970} + \cdots$, where w and 1-w are the weights, the coefficients bw and b(1-w) may be estimated by the regression and solved for w.

Geographic Mobility of Workers

The foregoing supply analysis is valid under the assumption of no geographic mobility of workers between labor markets. In a U. S. time-series analysis this assumption is closely met. But in a U. S. cross-sectional study where, e.g., states are the units of analysis, inter-market

[1]If college education is financed in substantial part out of savings from family income from previous years, then it would be desirable to use several family income variables for the years preceding 1960. However, this data are not available for states of the U. S. except for census years.

mobility modifies the supply model. If there is geographic mobility of workers between labor markets (states), there are two consequences. One is that the observed stock of college educated workers in a state is a function not only of the investment value of education (which determines how many people go to college in a state), but also of interstate movements of workers after they have completed college. Secondly, prospective college students may be aware of some probabilities of out-of-state employment and take out-of-state wages into account when determining their expected return to a college education.

The Effect of Migration on the Estimation of the Supply Model

When there is net interstate migration, the number of entrants into educated labor category L_i depends not wholly on the extent of investment in schooling by students in that state, but also partly on the number of workers with i years of school completed who move into that state from another state where they obtained their education. Likewise the number of workers who leave educated labor category L_i will depend not simply on deaths and retirements in that state, but also on outmigration. Of course if inmigration is equal to outmigration, the existence of mobility can be ignored. Only net inmigration or net outmigration is of any consequence.[1]

[1]This is true unless inmigrants have characteristics different from outmigrants such that median earnings are

What we desire to measure is the response of a state's residents to changes in the returns and costs of a college education in that state. But if there is net in-migration of college educated workers into a state, then the observed number of such workers will be higher than that due strictly to that state's benefits and costs of education, and conversely where there is net outmigration. Thus the existence of net interstate migration distorts the true relationship between the in-state determinants of the stock of college educated labor and the measured size of that stock currently in residence. In particular, the BEN_i variable in the supply equation will pick up the effect of net migration as well as the effect of the investment value of education on the stock of L_i, if high W_i is related to inmigration of L_i, because BEN and W_i are highly correlated ($r = .84$). This will result in an overestimate of the investment effect--an upward-biased regression coefficient.[1]

---

affected. Then W_i-W_j in the case of zero net migration will not be the same as W_i-W_j in the case of zero mobility, and the existence of mobility cannot be ignored.

[1]The magnitude of the bias depends on the extent of net interstate migration of college educated workers and on the relation between net migration and earnings. Neither of these can be definitively assessed. Over the period 1955-60, the 48-state average net interstate migration, regardless of direction, for all white males age 25-34, was 3.5 percent of that population. The correlation between the median annual income in 1959 of white males age 25-34 and their subsequent net interstate migration from 1965-70 was .008. Neither of these figures are specific to college educated workers and even if they were, it is difficult to say if they are large or small, or what other influences they may reflect.

The existence of net migration between states can be taken account of directly in a reestimation of the supply equation. Information on net migration of college educated workers for each state over the time span 1960 to 1970 can be used to correct the dependent variable, $L_{i,1970} - L_{i,1960}$, for net migration. By subtracting net inmigration and adding net outmigration, a reversion to the no-mobility model is obtained; migration is taken out of the observed L_i variable. Thus the true and single effect of the benefit and cost of college education in a state on the indigenous stock of college educated labor in that state is obtained.

Data on net migration by sex and age, but not by years of school completed, are available for the time span 1955-1960 by state. Data on mobility by years of school completed are available for the U. S. as a whole. More recent net migration data, not broken down by age, can be used to ascertain trends up to 1970 in net migration.

The Effect of Migration on the Specification of the Supply Model

The correction of the observed number of college educated workers in a state for the estimated number of net migrants is only a partial handling of the migration problem. This correction implicitly assumes that prospective college students use only a knowledge of home state earnings of college and high school educated workers to determine the benefit of a college education. But if there is interstate migration, there is some probability of obtaining not the home state benefit stream but rather the benefit stream of the state where employment is found. In fact if there is substantial interstate migration of college graduates which is responsive to geographic wage differences, then at the extreme one might hypothesize a national market for college graduates rather than a local (state) market. This implies that a college graduate in any state could obtain the "national" wage for college educated labor.

It is difficult to judge from the evidence available whether a state, regional, or a national market applies for college educated labor.[1] Therefore a supply function for college educated labor is specified under each of the three assumptions about the scope of the labor market.

Regional migration. The specification of the benefit of a college education used so far corresponds to a state labor market. Under the regional labor market assumption,

---

[1]There does not appear to be a single national wage since there is substantial variance in the median annual income of college educated workers across states, even after adjusting for absolute price level differences. But this variance could be due to state differences in unemployment, weeks and hours worked, age composition, industry mix, and quality of workers, as well as non-pecuniary compensating advantages. Crude evidence on the amount of migration and its responsiveness to wage differences (p. 39) is subject to alternative interpretations. Some studies of the relation between geographic migration and wage differences suggest it is significant but variable, depending on industry and worker characteristics. At the least there is consensus that distance is a strong deterrent to migration even in the face of wage differences, and that geographic labor markets work better and that migration is greater for more highly educated workers (see, e.g., Schwartz 1973, Gallaway 1967, Lansing 1967).

it is hypothesized that prospective college students are aware of the probability of interstate migration to neighboring states at the time they are making their college education investment decision (not just when their education is completed and they enter the job market). Then the benefit of a college education is constructed as the weighted sum of the home state benefit stream and neighboring state benefit streams, where the weights are the probabilities of migrating to each state. This is made empirically possible by actual 1960 data on the state of destination of outmigrants from each state of origin. Since in almost every case the overwhelming majority of outmigrants go to neighboring states, the regional labor market assumption is met. The actual effect of migration on the benefit of education variable is nevertheless quite small, since the number of migrants is small relative to non-migrants. Thus the home state earnings difference is still the chief determinant of the regional benefit term.

Formally, the regional benefit becomes

$$BENREG_{it} = \sum_{z=1}^{48} \sum_{t=m+1}^{k} \phi_z \cdot \frac{W_{itz}-W_{jtz}}{(1+r)^t} \qquad (12)$$

where ϕ_z = the probability of migrating to the z^{th} state (or of remaining in the home state) and z is an index over states. According to this formulation both college and high school graduates migrate; if a college graduate migrates he obtains the benefit stream of the destination state. Since it is empirically true that high school graduates migrate less than college graduates, a variation of the above formulation is attempted by assuming that net interstate migration by high school graduates is zero. In this case the benefit stream for the college graduate who migrates is composed of his destination state W_i, but his home state W_j, since the assumption is that he would not have migrated as a high school graduate. This changes the calculation of the regional benefit to

$$BENREG_{it} = \sum_{z=1}^{48} \sum_{t=m+1}^{k} \phi_z \cdot \frac{W_{itz}-W_{jth}}{(1+r)^t} \qquad (13)$$

where the symbol h indicates home state.

The regional labor market hypotheses are an additional variation on the question of how prospective college students determine their expected net return to the college education investment.

To simplify the calculation of the regional benefit term under these hypotheses it will be assumed that if interstate migration occurs, it does so once, at the completion of college education. Thus a college educated worker obtains either his home state return or an out-of-state return, but not some of each.[1]

[1]The implicit assumption in this section is that migration is determined outside the supply model. Observed interstate migration is used as an exogenous variable to modify the calculation of the home state earnings return to a college education. But if interstate migration depends importantly on earnings differences between states, then

<u>A national labor market for college educated workers.</u> Under the national labor market assumption, there is a single national earnings figure for college educated labor which any college graduate can obtain. It is therefore constant for all states. Although there are in fact differences across states in W_i, the state earnings figure is not relevant.[1] The national earnings figure is relevant because those earnings are obtainable by all via migration which is assumed responsive to wage differences. The national earnings figure is indicated by the U. S. aggregate median earnings for college educated workers, $\overline{W}_i$. This figure is used by prospective college students to determine their benefit from college education. The benefit term under the national labor market assumption becomes

$$BENNAT_{it} = \sum_{t=m+1}^{k} \frac{\overline{W}_{it}-W_{jt}}{(1+r)^t} \qquad (14)$$

---

the two variables are simultaneously determined and a model linking them would be desirable. No such effort is made in this study, partly because it is likely that the effect of the earnings difference on migration occurs only after a lag, and partly because a migration model would likely be unsuccessful, given the high level of aggregation of the data in this study (see the note preceding). In any event, the overall effect of actual migration on the benefit of education variable is small since the number of migrants is small relative to non-migrants. Thus the home state earnings difference is still the chief determinant of the regional benefit term.

[1]These differences are attributed to the factors enumerated in the note on p. 41.

The supply equation specified with the national earnings benefit term provides a test of the college decision process as it relates to the prospective student's perception of geographic mobility and hence the applicability of state, regional or national markets to the college education decision.

The Supply of Young College Educated Labor (Age Group 25-34)

A supply equation can be obtained for young college educated workers, age group 25-34 (rather than age group 25+). It is obtained by a mathematical simplification of equation (3), p. 9. The main reason for making this age disaggregation is to give a theoretically simplified supply equation. Estimation is permitted by the availability of data on the number and earnings of workers by years of school completed by age group for states in 1970.

If the number of years spanned by the age group is the same as the number of years spanned by the two time points at which measurements on L_1 are taken, then two variables in the supply equation drop out. The dependent variable becomes a level rather than a rate of change variable, and the right hand side variable for the number of leavers from the educated labor category L_1 drops out. Rewrite equation (3) as

$$L^*_{1t_o} = L^*_{1,t_o-n} + \sum_{t=t_o-n+1}^{t_o} L^{e*}_{1t} - \sum_{t=t_o-n+1}^{t_o} L^{d*}_{1t} \qquad (15)$$

where the asterisk superscript indicates the age group 25-34 of members of educated labor category L_i. In general the number of leavers, $\sum_{t=t_o-n+1}^{t_o} L_{it}^{d*}$, is affected by the initial stock, L_{i,t_o-n}^{*}, since departures from educated labor category L_i^*, when L_i^* refers to a particular age group, occur by aging, i.e., by getting too old to be included in the age group. Now take the age group to be 25-34 years old, and again let t_o = 1970 and t_o-n = 1960. Then in the absence of migration, the number of leavers from educated labor category L_i in 1961 is given by the number of workers who became 35 years old in that year, which is the number of workers who were age 34 in 1960, and by the number of deaths. In 1962 the number of leavers by aging is given by those who became 35 in 1962, which is the number who were 33 in 1960. In similar fashion, the number of leavers by aging in 1970 is given by those who were age 25 in 1960. Thus $\sum_{t=1960}^{1970} L_{it}^{d*} = L_{i,1960}^{*}$. All of those college educated workers who were age 25-34 in 1960 have left this educated labor category by 1970. All of those who are now in this category entered between 1960 and 1970. Thus equation (15), for workers with i years of school completed who are 25-34 years old in 1970, can be rewritten by deleting the two terms above since they are equal and of opposite sign. The supply equation becomes

$$L^*_{i,1970} = \sum_{t=1960}^{1970} L^{e*}_{it} \qquad (16)$$

The supply relation under the assumption of no inter-market mobility of workers, when L_{it} is disaggregated by age, and when the age group is a young age group spanning as many years as those over which the change in L_i is measured, can be written

$$L^*_{it_o} = S^*(R_{i,t_o-n}, L_{j,t_o-n}, Y_{t_o}, LOAN_{t_o}) \qquad (17)$$

where $t_o = 1970$, $t_o-n = 1960$, and the age group is age 25-34.

If migration is allowed, then $\sum_{t=t_o-n+1}^{t_o} L^{d*}_{it}$ re-enters equation (15) redefined as the number of leavers due to outmigration. A correction of $L^*_{it_o}$ for net migration can be made in the same way as described for the age group 25+, above.

The difference between the supply equations for the two age groups (equation [17] for age group 25-34 years and equation [10] for age group 25+) is strictly a mathematical outcome. The same phenomenon is being explained by the same right-hand side variables in each equation, namely the number of entrants into the category of college educated labor from 1960 to 1970. The entrants are the same people in each case. Note that the supply equation for age group 25-34 explains the level rather than the rate of change of the stock of college educated labor. In the supply equation for age group 25-34, the beginning (1960) level variable conveniently drops out, leaving the current (1970) level as a function only of the determinants of the number of entrants over the decade 1960-1970. Thus an explanation of the level can be achieved without regard to past events or the historical pattern of educational development, both of which would ordinarily be reflected in the current level. It is for this reason that no large differences should be expected in the coefficients of the supply equations for the two age groups even though one equation explains a rate of change and the other a level.[1]

[1]Nevertheless further comparisons can be made between the results for the two age groups by estimating two additional equations. The equation for the age group 25-34 can be estimated as a rate of change equation rather than as a level equation by simply not making the mathematical simplification of equation (15). The equation for age group 25+ can be estimated as a level equation under the assumptions of the special case described on page 10.

CHAPTER III

THE SUPPLY FUNCTION FOR FEMALES

The supply relation for educated labor has been specified generally using human capital variables (the benefits and costs of education), a consumption demand and an ability to pay constraint (represented by family income and government loans), and the number of eligible prospective students. This model is valid for men. But there are differences in the effects which human capital variables have on the supply of college educated women. These issues are discussed in this chapter.

Female Labor Force Experience

On the average women who are in the labor force spend fewer years of their life-cycle in the labor force than do men. For this reason women will obtain a smaller net return to their college education investment, since there are fewer years over which they capture the benefits of a college education. This is especially true because working women are most likely to be out of the labor force in the child-bearing years, early in their employment cycle, when the discounting of the wage difference between college and high school educated workers is small. But the U. S.

Census data does not reflect this male-female difference in the number of years spent in the labor force. Therefore the net return to education for females will be calculated with error because it implicitly assumes labor force participation every year.

Formally, the benefit of education from labor market employment includes a variable, T_t, which has the value one if the person is employed and zero otherwise:

$$BEN_{it} = \sum_{t=m+1}^{k} \frac{W_{it}-W_{jt}}{(1+r)^t} \cdot T_t \qquad (18)$$

For college educated males, T_t is almost always one, but for females there are many years when it is zero. In addition, the number of years of female labor force experience affects earnings in the years when females are working since the less experience a woman has, the smaller her earnings will be. Thus the female BEN_{it} term should be further adjusted by reductions in W_{it} and W_{jt}. The size of the reductions depends on the amount of female labor force experience.

A recent study by Mincer and Polachek (1974) permits a crude correction to be applied to the female benefit term as calculated from U. S. Census data. Their work on the work histories of white and black women age 30-44 yields the information that white women with 16 or more years of school completed who worked in 1966 spent on the average about 60 percent of their years since college graduation in the labor force. For white women with 12-15 years of school completed the corresponding figure is about 52 percent.[1] Another finding of the Mincer-Polachek work is that the number of years of labor force participation for white females depends most importantly on whether the woman is married with children or whether she is childless, either never-married or married without children. For the U. S. in 1966, white females age 30-44 who were never married worked 91 percent of the years since the completion of their schooling, and white females who were married but childless worked 81 percent of the time. On the other hand, white females who were married once (spouse present) and who had children worked only 38 percent of the time. These results are used to construct an indicator for female labor force experience for each state.

There is data for states on the number of never-married females and the number of childless married females, by race and years of school completed. Data on these two variables can be combined into a single index for the number of childless college and high school educated females since the effects on female work history of being never-married

[1]Unfortunately, the distribution of the years of labor force participation over the life cycle, which affects the present value of future income, cannot be determined. It is of course known that women commonly work the first few years after completing their schooling, then are out of the labor force for several years during child-bearing and child-rearing years, and then return to work. This pattern may not be substantially different from a pattern of an even distribution of working in terms of the present value of future income.

or of being married but childless are similar. This index of state female labor force experience is used to modify the U. S. average percent of years worked (from Mincer-Polachek) for each state. Then the observed W_i and W_j from the U. S. Census data is reduced using the state experience variable. This yields a corrected female benefit of education term which reflects both the existence of years of non-participation and differences in labor force experience associated with differences in educational attainment.

Household Returns and the Education Decision

The time that women do not spend in the labor force they spend in household activities. Recently some attention has been given to the relation between the amount of human capital possessed by women and various aspects of their non-labor-market behavior, such as marriage, fertility, child rearing, and the production of household tasks.[1] For those women in the labor force who are not or do not intend to be professional career women, a household return rather than a market return may be one reason why they make the college education investment. The household return may be non-pecuniary, such as increased efficiency in the production of household tasks and higher quality children, or it may be a pecuniary return, such as higher family income.

---

[1]See The Journal of Political Economy 81, Pt. II (March/April 1973), and 82, Pt. II (March/April 1974), for a discussion of some of these arguments and a list of references.

For some women, going to college may be a way to increase their future family income in two ways. First, by going to college, they increase their range of marriage opportunities, in particular the chances of marrying a college educated husband with high income and professional occupation prospects.[1] Second, by getting more education, wives may be able to increase their husband's income, given their husband's education and job experience (Benham 1974).[2] The family income benefit is an economic return to women but it is a household return rather than a market return since it does not depend on female labor force participation. This kind of pecuniary household return may be relevant to women who plan to be married and have children and who therefore are (statistically) likely to spend some years out of the labor force. It may not be relevant for women who plan to work continuously throughout their life cycle in professional employment. Also, if a female does

---

[1]The argument is not the traditional and partly facetious claim that girls go to college to find a husband. Most females who want to marry have ample opportunities to do so without going to college; but by going to college they expand their range of choice--they enter a different "marriage market." The argument does not deny that there may be desirable non-economic characteristics of college educated men. Also "marriage market" motivations may be operative in men as well as women. It is only because of the non-continuous labor force participation of most college educated women that it is necessary to invoke the household returns hypothesis for women.

[2]Benham suggests that human capital is formed within the household, as well as in formal schooling and in job training. The process may be one of the spouse serving as a close substitute for the partner's own formal education by helping acquire information, skills and advice.

not plan to be employed after college graduation (and hence pays little attention to the immediate market benefits and costs of a college education), she may nevertheless realize the financial security of a college education in the event she is later forced into the labor force. Females may go to college for long run family income reasons, or for "insurance" reasons.

Women who invest in a college education for a household return reason will not be responsive to changes in their market net return to a college education. Rather, their purchase of a college education is to be explained by the non-market household return and a consumption demand. In other words, a simple model is that while most men invest in college education to get a pecuniary market return, only some women make the investment for that reason, while others do so to obtain a household return. If this is true, then in the aggregate the response of women to changes in the market net return will be less than the response of men. Proportionally fewer women than men are motivated to invest in a college education for its market return. For those who are not so motivated, changes in the market return will have no effect, and in the aggregate the coefficient on the market net return will be smaller for women than men. That is, college-going for women may be viewed as an average of two probabilities. For one group of women, the probability of going to college, given a change in the market return, may be the same as that for men. For the other group, the probability is less, maybe zero. The supply equation, for both groups in total, estimates a weighted average probability which is less than that of the former group by itself. The hypothesis to be tested is that the supply of college educated females will respond weakly if at all to changes in the female market net return to college education.

Empirical specification. There remains the question of how to specify the equation for the supply of college educated women to take into account the pecuniary household return hypothesis. First, an attempt is made to distinguish between observations on the expected strength of the market return vs. household return reasons for investing in a college education. This approach permits the market net return variable to take on different coefficient values depending on its relevance to different observations. Secondly, an empirical formulation of a household return variable is entered in the supply equation. It is weighted with the market return variable according to the proportion of women for whom its effect is expected to be important.

In the first approach, it is hypothesized that the market return is most relevant to women when they are engaged in labor market activities (i.e., obtaining a market return) and that they are more likely to be in the labor force if the market return exceeds the household return.[1]

[1]I am indebted to Jacob Mincer for suggesting this possibility.

Conversely, if the household return exceeds the market return, females are less likely to be in the labor force and more likely to be engaged in household activities. If this is true, then information on female labor force participation can be used to indirectly indicate the cases where the market return is likely to be a relevant college education decision variable. The U. S. has in the past had a very rapid increase in the labor force participation rate for young (age 25-34) college educated women. This may reflect a response by women to obtain a (high) market return, in excess of a household return. In such a case the market return is likely relevant to the college education decision of women. On the other hand, if the increase in the labor force participation rate is small or even negative, it may imply the market return is less than the household return. In this case the market return would not be an important decision variable.

In sum, the market return is important to the college education decision if it exceeds the household return, because then participation in the labor market is more likely. Therefore, labor force participation data can be used to distinguish states where the market return is likely to have an important effect on the supply of college educated women.[1]

[1]An alternative means of distinguishing between states on the relevance of the market return is to use the finding that women who are single or married but childless have a labor force participation history which is very similar to that of men (continuous working). The market return is relevant for childless women. However, it is

Econometrically this can be accomplished by the use of a dummy variable. In particular, the supply equation is written with a multiplicative dummy variable added. (For illustration a functional form is specified which is linear in logarithms because that is the form which is used for the estimation work later on, but that choice is irrelevant to this illustration):

$$\ln L_1^* = a_o + a_1 \ln BEN + a_7 \ln (BEN * DUM) + a_2 \ln COST + a_3 \ln HS + a_4 \ln Y + a_5 \ln LOAN + a_6 \ln Q + u \qquad (19)$$

where DUM in the new variable BEN * DUM is a dummy variable which takes the value zero if the increase in the labor force participation rate for females age 25-34 from 1950 to 1960 was much below average, and one otherwise. This procedure permits the coefficient of BEN to take on two different values. If DUM = 1 (indicating that the market return is likely to be relevant) then the regression equation becomes $\ln L_1^* = a_o + a_1 \ln BEN + a_7 \ln BEN + \ldots$ and the coefficient of BEN becomes $a_1 + a_7$. If DUM = 0 (indicating that the market return is not relevant), then the coefficient of BEN is just a_1.[1]

---

unlikely that marital and family status can be well predicted by 18 year old girls. Furthermore, this variable would not distinguish the relative attractiveness of the market return for women who plan to have children but also work. Therefore this approach was not used.

[1]The change in, rather than the level of labor force participation is used because the latter is more likely to

The second approach to the household returns problem requires that the household return be empirically specified. Since it is clearly not a uni-dimensional variable, only a partial representation of it can be achieved. One dimension of the pecuniary household return obtained by women as a result of college education is higher family income. This benefit depends on marrying a husband with high income and occupation prospects, and on enabling the husband's income to be higher, given his education (see p. 52).

The household benefit can be specified in two alternative ways. First, the market benefit obtained by college educated men, rather than women, can be used in the supply equation for women. If women pay little attention to their market benefit of a college education because they expect to spend many years out of the labor force, but women do go to college to get the specific household return of a higher income husband, then the male benefit term should have a positive effect on the supply of female college educated workers. Of course not all women choose to marry, so high income husbands are not relevant in all cases. Thus a correct specification would include the male market benefit weighted by the proportion of college educated women who are married, plus the female market benefit

reflect economic and social characteristics (such as industrial structure, level of income per capita, and attitudes about equal rights for women) which may not be related to the size of the market return relative to the non-market return for college educated women.

weighted by the proportion of females who are single. Additionally, a new variable should be added to the supply equation: the ratio of male enrollment to female enrollment in colleges. Under the "marriage market" hypothesis, the probability of success as well as the size of the payoff is important; the higher the male/female enrollment ratio, the higher the probability of marrying a high-income male.[1]

A second way to specify the household benefit for women is to use information on the family income of families where the wife is college educated vs. families where she is high school educated. This measure would incorporate both the probabilities of marrying a higher income husband and the increased chance that a college educated married woman would herself spend more time in the labor force and thus contribute to family income. The same weighting procedure as above applies to this family income specification of the household return.

Other Male-Female Differences

In determining the specification of the supply equation for college educated labor, it was assumed that private capital markets for the individual finance of investments in higher education do not exist. The ability to pay for a college education, indicated by income and by government loans, was therefore a determinant of the supply of educated

[1]Of course if a high male/female enrollment ratio encourages more women to enroll, the ratio will decline, unless there is a counter-response by men.

labor. Since female students have smaller part-time earnings than males, they are less able to pay, and so more females than males are prevented from going to college on this account, given the same net return. If the net return is favorable, not only will there be fewer college educated women than men, but also the responsiveness of women in the aggregate to changes in their ability to pay will be greater than for men. When the ability to pay of women goes up, proportionally more will then be able to make investments in college education, given a favorable net return, because proportionally more were previously prevented from doing so by an inability to pay.

If fewer women than men regard education as an investment good, then more women than men regard education as a consumption good, or as a good yielding non-pecuniary returns (the household return of higher quality children is an example). In the aggregate the quantity response of women to changes in the determinants of the non-pecuniary consumption demand a household return for education should be greater than the quantity response of men to these variables. That is, while the market or investment net return to education has a stronger effect on the aggregate supply of college educated men in the labor force than it does for women in the aggregate, the reverse is true for non-market, non-investment returns. Since more women than men are motivated to purchase a college education for reasons of obtaining consumption benefits, the income variable, which affects the purchase of education as a consumer good, is expected to have a stronger effect on the aggregate supply of college educated women than it does for men.

An additional problem with the market net return variable is that it contains an assumption about how prospective students form expectations about future earnings which may not be true. If earnings by level of educational attainment are stable over time, then the expectations hypothesis is less critical than if earnings change rapidly. If the earnings of women are less stable than those of men, then we would expect the market net return variable to perform less well in explaining the stock of educated women because the calculated net return to education used in the analysis would be less likely to correspond with the students' calculations of the net return to education.

CHAPTER IV

THE DEMAND FOR COLLEGE EDUCATED LABOR

A major hypothesis of human capital theory is that workers with different levels of educational attainment constitute different factors of production, and can therefore be considered separately in the analysis of labor markets. The disaggregation of heterogeneous labor into several separate factors, distinguished by educational attainment, has shown its analytical value.[1] A labor market analysis was used in a recent study of the nature of the dynamic price and quantity disequilibrium adjustment process for certain college educated labor specialties (Freeman 1971).

In this paper college educated labor is treated according to conventional factor demand theory. An aggregate demand function for college educated labor is derived from neoclassical production function theory. The parameters of the demand function are estimated in a U. S. cross-sectional analysis. The results from the demand model are put together with the results from the supply model to provide a labor market interpretation of the price and quantity

[1] See, for example, the work on the explanation of economic growth of Denison (1962), Griliches (1964) and others.

behavior of college educated labor in the U. S. A knowledge of the responsiveness of the quantity of college educated labor demanded to changes in its price and to changes in demand curve shifters is also useful as a guide to manpower policy.

In general, the demand for a factor of production depends on the price of the factor and on factor demand curve shifters, which are the conditions of supply of related factors of production and the conditions of demand for final output, with the production function for final output given. The specification of the conditions of supply of related factors and the conditions of demand for final output depends on the market structure, the unit of analysis, and the length of run. For a firm in competitive factor and output markets, the correct specification includes the prices of related variable factors of production, the quantities of related fixed factors, and the price of output.

In this study the unit of analysis is not the firm, but rather the labor market, which is empirically approximated by states of the U. S. The task at hand is that of specifying an aggregate demand equation for educated labor by a state. This raises two questions: What are the explanatory variables, and what is the functional form of the equation?

The technique of formally deriving a firm-level factor demand equation from the profit maximization conditions of the firm is well established in the neoclassical theory of the firm. In this study an aggregate rather than a firm-level factor demand equation is required. It has recently been shown by Gould (1966) that such an aggregate factor demand equation can be obtained by a modification of the firm-level derivation which reflects the difference in the level of analysis. Such a derivation will dictate the variables which enter the equation and the functional form of the equation. The resulting aggregate factor demand equation reflects the conditions on the supply of related factors of production and the conditions of demand for final output which the use of states as units of analysis imposes. This demand theory, developed in the following pages, will be applied to the analysis of the demand for college educated labor by states of the U. S. A variant of the Gould model worked out by Waud (1968) forms the basis of the following section.

A Three Factor Model

The demand theory begins with the derivation of a factor demand curve for a firm. Consider a model in which there are three factors of production, L_i, L_j, and K, where L_i and L_j denote labor of different educational attainments and K is physical capital (e.g., L_i might be workers with a college education and L_j workers with a high school education). The objective of each firm is to maximize profits, π.

$$\pi = pq - W_iL_i - W_jL_j - RK \qquad (20)$$

where p is the price of output, q is the quantity of output, and W_i, W_j, and R are the prices of the factors L_i, L_j, and K, respectively. Take the production function to be Cobb-Douglas,

$$\pi = AL_i^{\alpha_i} L_j^{\alpha_j} K^{\beta} \qquad (21)$$

Maximizing (20) with respect to L_i leads to the marginal productivity relation for L_i,

$$\frac{\partial \pi}{\partial L_i} = p\alpha_i AL_i^{\alpha_i - 1} L_j^{\alpha_j} K^{\beta} - W_i = 0 \qquad (22)$$

and from (22),

$$\frac{\partial \pi}{\partial L_i} = \frac{\alpha_i q}{L_i} = \frac{W_i}{p} \qquad (23a)$$

The same procedure may be repeated for each factor, yielding

$$\frac{\partial \pi}{\partial L_j} = \frac{\alpha_j q}{L_j} = \frac{W_j}{p} \qquad (23b)$$

$$\frac{\partial \pi}{\partial K} = \frac{\beta q}{K} = \frac{R}{p} \qquad (23c)$$

Note that the analysis so far is for firms operating in competitive factor and product markets. Each firm therefore faces an infinitely elastic product demand curve and determines output by equating price and marginal cost. (If, however, the assumption of pure competition among firms is dropped, or the analysis is for a monopolistic firm, then the price variable, p, in equations (23a), (23b), and (23c) is replaced by marginal revenue, $MR = p(1+1/\eta)$, where η is the price elasticity of the demand curve for output faced by the firm.)

To obtain the expression relating L_i, W_i, and the other factors of production, substitute (21) into (23a),

$$W_i = \frac{p\alpha_i A L_i^{\alpha_i} L_j^{\alpha_j} K^{\beta}}{L_i} \qquad (24)$$

In the analysis of the demand for a factor of production by a firm in competitive factor markets, usually assumed that the supply curves of the other factors of production, in this case L_j and K, are perfectly elastic. The firm can employ any amount of these factors without affecting their prices. In this case the demand equation for L_i would be written in terms of the prices of L_j and K (W_j and R respectively), and not in terms of their quantities as in equation (24). But when states of the U. S. are the units of analysis rather than the firm it is not clear that this is the correct specification. Ideally in studies such as this, one would hold constant the supply <u>curves</u> of related factors of production. The assumption of perfectly elastic supply of related factors is an empirical compromise. The consequences of using such an assumption have been noted by Waud (1968) and Gould and Waud (1970).

If the foregoing derivation is continued under the assumption that the supply curves of the factors L_j and K are perfectly elastic, each must be replaced in (24) by expressions for L_j and K in terms of W_j and R, respectively. Solving (23a) for q and substituting into (23b) and then (23c) leads to an expression for L_j in terms of W_i, W_j, and

L_i, and an expression for K in terms of W_i, R, and L_i. Substituting these expressions into (24) gives

$$W_i = p\alpha_i A L_i^{\alpha_i} \left(\frac{W_i}{W_j}\frac{\alpha_j}{\alpha_i}\right)^{\alpha_j} \left(\frac{W_i}{R}\frac{\beta}{\alpha_i}\right)^{\beta} L_i^{-1} \qquad (25)$$

For firms in a competitive product market, p is a given and is equal for all firms. Thus each firm has equal marginal cost of production as a direct result of the profit maximizing condition of p = MC, and in long run equilibrium each firm also has equal average cost so that p = MC = AC. For states of the U. S., a national product market can be assumed so that p is equal in every state. Hence for the aggregate factor demand equation the p = MC condition is also imposed. However, for some states of the U. S., p may not be a given; some states may not be price takers. Several states account for a substantial share of total U. S. output and thus would be able to affect p by virtue of their economic activity (e.g., California accounts for about 11.3 percent of U. S. personal income [GNP data is not available by state], New York has 11.0 percent, and Illinois 7.0 percent, in 1970). Therefore p can be replaced by the output demand schedule faced by the state. Let the output demand equation be

$$p = Dq^{\gamma} I^{\delta} \qquad (26)$$

where $\gamma = 1/\eta$ and I represents output demand curve shift variables, not yet specified. (If the output demand equation were written with q on the left hand side then the price elasticity of demand for output, η, would be the coefficient of p on the right hand side, given this functional form.) Substituting (26) into (25), simplifying, and making L_i the dependent variable, we get the factor demand equation for L_i:

$$L_i = \left(\frac{\alpha_i}{W_i}\right)^{\frac{1-a(\alpha_j+\beta)}{b}} \left(\frac{\alpha_j}{W_j}\right)^{\frac{a\alpha_j}{b}} \left(\frac{\beta}{R}\right)^{\frac{a\beta}{b}} (I)^{\frac{\delta}{b}} (DA^a)^{\frac{1}{b}} \quad (27)$$

where $a = 1+\gamma$

$b = 1-a(\alpha_i+\alpha_j+\beta)$.

The differences between this aggregate factor demand equation (27) and the factor demand equation for a firm in pure competition are in the exponents on the factor price variables, the presence of the aggregate output demand curve shift variable I, and in the constant term. All of these differences are directly traceable to the substitution of a function for p in the place of p. In the factor demand equation for a firm, the assumption is required that $\alpha_i+\alpha_j+\beta < 1$. When the output demand curve is perfectly elastic, decreasing returns to scale are required to obtain a solution to the profit maximization problem. Unless average costs rise in the long run, the firm's output is infinite or indeterminate. In the aggregate factor demand equation, constant returns to scale can be handled since

$b > 0$ in absolute value must always be true, even if $\alpha_i+\alpha_j+\beta = 1$ because $a \neq 1$ as long as $-\eta < \infty$. The downward sloping demand curve for output provides a determinate long run output under both decreasing and constant returns to scale. Increasing returns to scale can be handled as long as output price falls faster than average cost as quantity increases, which requires that $-\eta < \alpha_i+\alpha_j+\beta$.

If logarithms are taken on both sides, (27) can be written as a linear regression equation,

$$\ln L_i = -\left[\frac{1-a(\alpha_j+\beta)}{b}\right] \ln W_i - \frac{a\alpha_j}{b} \ln W_j - \frac{a\beta}{b} \ln R + \frac{\delta}{b} \ln I + C \qquad (28)$$

where the constant term $C = (\alpha_i)^{\frac{1-a(\alpha_j+\beta)}{b}} (\alpha_j)^{\frac{a\alpha_j}{b}} (\beta)^{\frac{a\beta}{b}} (A^a D)^{\frac{1}{b}}$.

The signs of the coefficients of the factor demand equation can be predicted on a priori grounds. The sign of the coefficient on the own-wage term W_i will ordinarily be negative. It can only be positive if there are increasing returns to scale. This is a necessary but not sufficient condition for a positive own-wage coefficient. In addition, the price elasticity of demand for output must be elastic and high. The signs of the coefficients on the prices of related factors of production may be either positive or negative, depending on the price elasticity of demand for output and the nature of scale returns. If the price elasticity of demand for output is inelastic, then these signs will be positive. If the price elasticity of demand for output is elastic, these signs will be negative unless there are increasing returns to scale. If these are increasing returns to scale, the signs may be either negative or positive. A positive sign is more likely if output demand is very elastic and/or increasing returns to scale are substantial.

Issues in Estimating the Demand Model

Several issues may be raised before the factor demand equation derived above is estimated. They concern (1) the form of the production function, in particular whether the Cobb-Douglas functional form is appropriate, (2) the location of production by industry--its implications for the estimation of a cross-sectional derived demand equation, and (3) the treatment of output demand curve shift variables.

The form of the production function. Since the factor demand equations finally obtained from this profit maximization model are influenced by the form of the production function chosen, one should ask about the suitability of the Cobb-Douglas production function for this analysis. In particular, one should ask whether the implication that the elasticities of substitution between all factor pairs are constant and unitary is fulfilled in practice. In his testing of this implication, Griliches (1964) concluded that there is no strong evidence against the Cobb-Douglas form in manufacturing industries or in agriculture. This conclusion was obtained from experiments with a labor demand equation derived from the CES production function. It also applies to a direct test on the CES function. Although the factor inputs in these tests were undifferentiated labor and all other physical capital inputs, Griliches made an attempt to take into account differences in the quality of labor by introducing a separate education variable. The estimated elasticity of substitution was not consistently or significantly reduced below unity. (See Griliches [1964, 1967] for a thorough discussion of this matter.) However, in a later study, Griliches (1969) suggested that skilled labor is more complementary with physical capital than is unskilled labor. And recently Berndt and Christensen (1974) concluded that the Allen partial elasticities of substitution between pairs of inputs were quite different.[1] These latter two studies cast some doubt on the suitability of the Cobb-Douglas function. But they both disaggregate labor by occupation rather than by education. Since the link between occupation (as defined in government data sources) and education is weak (Bowman 1972) and since the earlier Griliches study incorporated an education variable, evidence is unclear, and the Cobb-Douglas function is used in this study.

---

[1]They estimated average values of 3.72 between blue collar production workers and physical capital, -3.77 between white collar nonproduction workers and physical capital, and 7.88 between production and nonproduction workers in U. S. manufacturing industries.

The location of production. The demand for a factor of production is a derived demand and this study is a cross-sectional study. Therefore theoretical assurance is needed that not all of any given industry's output will be concentrated in a single state. Three arguments can be made. First, the expansion of an industry in a state via increasing firm size would ordinarily be limited by decreasing returns to scale. Secondly, the expansion of an industry in a state via increases in the number of firms (i.e., by entry or by firm mobility), would ordinarily be limited by the phenomenon of an increasing cost industry. Thirdly, even in the absence of increasing costs, factor mobility may occur to equalize the average cost of production for firms in the industry across states and thus prevent the concentration in any one state. These three considerations--decreasing returns to scale for the firm, increasing costs for the industry, and factor mobility--may serve to prevent the concentration in the long run of an industry in a single location. And no such concentration is observed in practice. Therefore the cross-sectional empirical analysis can proceed.

The treatment of output demand curve shift variables. The formulation of the output demand curve shift variable I depends on the unit of analysis. For a competitive firm, I is replaced by p, the price of the output. For a competitive industry or a monopoly firm, I should reflect variables such as income, tastes, prices of related goods, and population. In this study the labor market is the unit of analysis, which, due to data availability, is taken to be states of the U. S. If observations are taken on states, the output Q is heteroegenous, covering most or all industries, while the labor factors are homogeneous with respect to quality or skill, insofar as that is represented by formal schooling. Therefore, indicators for shifts in demand for aggregate output, such as state or national income, need not have significant effects on the demand for particular educated labor factor L_i. If there are differences in educated labor factor intensities across industries, then the derived demand for particular educated labor factor L_i depends on the industrial composition of aggregate output as well as on its level. Thus the industry mix in a state becomes a shift variable in the demand for educated labor factor L_i. Furthermore, if there are national product markets, state income would not be the determinant of state production and on this account also would not be a demand shift variable. Only some service industries have local or state markets and would be affected by state income.[1]

One way to represent the industry mix in a state is to use a series of variables, each indicating the size of a

[1]The educational services industry may be one example which is relevant for women. The market is chiefly local or state, and if the teacher/student ratio is affected by state income, then the demand for college educated women may also be affected.

particular industry. Industries may be defined in terms of educated labor factor intensities. This can be determined from U. S. data on the educational distribution of employment in detailed industries.

At best, using a series of industry variables is only an approximate control for industry mix, since industry data is not organized by factor intensity. A more exact way to represent variation in the industrial composition of output follows from a relation obtainable from the Cobb-Douglas production function. From (23a) and (23b), the relationship between a factor quantity ratio and a factor price ratio is obtained:

$$\frac{L_i}{L_j} = \frac{W_j}{W_i} \cdot \frac{\alpha_i}{\alpha_j} \qquad (29)$$

The ratio of the two educated labor factors L_i and L_j is equal to the inverse ratio of their wages multiplied by the ratio of the production coefficients of the factors. Because the simple correlation between L_i/L_j and W_j/W_i across states is not perfect ($r = .255$), that means each state has different coefficients α_i, α_j on its aggregate production function. This may be explained by differences in the industrial composition of output (i.e., a given industry has identical production functions across states, but each different industry has different coefficients). Therefore, the ratio α_i/α_j which satisfies the equation above for each state is a reflection of the industry mix in each state. Variation in α_i/α_j across states is due to variation in industry mix, and that explains the departure of the observed L_i/L_j ratio from that which would be observed given the prevailing wage ratio and industry homogeneity. The ratio α_i/α_j may therefore be used in the educated labor demand equation as the industry mix demand curve shift variable. The industry mix in each state is assumed to be predetermined. It is an exogenous variable in the factor demand equation.[1]

Finally, a third way to proceed is to avoid the industry mix problem altogether by disaggregating factor quantities and prices by industry, taking data on L_i, W_i, W_j, and R by industry, and then building up total L_i by summing across industries, $L_i = L_{iA} + L_{iB} + \ldots + L_{iZ}$, where the subscripts A, B, ... , Z indicate the industry for which L_i is explained. This procedure entails the specification and estimation of demand equations for L_i for each industry considered.[2] But the approach of disaggregating by industry

[1] Firms display some geographic mobility as well as workers, so one might ask if the location of production is determined by L_i and is thus not exogenous. But it is factor prices (operating via cost functions) rather than factor quantities that determine the location of an industry's output. Of course L_i and W_i are simultaneously determined, so L_i may affect the state industry mix indirectly via its effect on W_i. But the location of industries would adjust to changes in L_i only with a lag. In the factor demand equation, L_i is contemporaneous with the industry mix variable, thus ensuring that it is endogenous.

[2] Following the technique used to obtain (27), these demand equations can be shown to be of the form

is not possible since there is no data on years of school completed by industry or on earnings by years of school completed by industry for states of the U. S. except for the agriculture industry. (The quality of labor variable which Griliches [1967] used in his estimates of the U. S. manufacturing production function was constructed using occupation rather than education data.) Thus we are left with either specifying a series of industry variables, or using the ratio of production coefficients α_i/α_j to imply the industry mix more exactly.

$$L_{iA} = \frac{\alpha_{jA}}{W_{iA}}^{\frac{1-a_A(\alpha_{jA}+\beta_A)}{b_A}} \frac{\alpha_{jA}}{W_{jA}}^{\frac{a_A\alpha_{jA}}{b_A}} \frac{\beta_A}{R_A}^{\frac{a_A\beta_A}{b_A}} Y_A^{\frac{\delta_A}{b_A}} D_A A^{a\frac{1}{b_A}}$$

where $a_A = 1+\gamma_A$
$b_A = 1-a_A(\alpha_{iA}+\alpha_{jA}+\beta_A)$.

To obtain the demand equation for L_{iB}, ... , L_{iZ}, simply substitute B, ... , Z wherever A appears above. Note that estimating L_i as $L_i = f(L_{iA} + L_{iB} + \ldots + L_{iZ})$, where $L_{iA} = f_A(W_{iA}, W_{jA}, R_A, Y_A)$, $L_{iB} = f_B(W_{iB}, W_{jB}, R_B, Y_B)$, ... , $L_{iZ} = f_Z(W_{iZ}, W_{jZ}, R_Z, Y_Z)$ involves non-linear estimation since $\ln L_i = \ln(f_A + f_B \ldots + f_Z)$ and f_A, f_B, ... , f_Z are each themselves multiplicative functions. Thus ambiguity due to the non-uniqueness of the parameter estimates is encountered.

CHAPTER V

ESTIMATION OF THE SUPPLY MODEL: WHITE MALES

The supply model is estimated from U. S. cross-sectional data, with states as the units of analysis. The supply of college educated white males is measured in 1970. Supply determinants are measured in 1960. Before estimating the equations, two empirical problems need to be taken up.

Empirical Problems

One empirical problem is variation across states in the quality of schooling, and in the possibility of rationing of places in colleges. The other is variation in measured earnings data due to differences in the absolute price level across states.

Quality of schooling and rationing of places. There are two aspects of the quality of college education. One is schooling quality which produces an objectively better qualified graduate and which is subsequently reflected in the earnings of college educated workers (albeit imperfectly and perhaps with a very long lag). High quality states would on this account be expected to have more college educated workers than low quality states via higher net returns to college education. There may also be immediate and ultimate amenities of schooling which are non-pecuniary and which do not affect market wages, but which do affect college-going decisions. (Examples are personal associations and physical environment.) Therefore the equations for the supply of college educated labor should contain a variable for non-market quality of schooling. This dimension of school quality can vary independently of the private benefits and costs of schooling and may affect the supply of college educated workers.

At the same time that the quality of schooling in a state may affect the desirability of college attendance, a shortage of places in colleges may constrain the ability of prospective students to attend college in that state. A common view heretofore has been that rationing of places in colleges really was not a constraint on college attendance in the aggregate--there was always some college for everyone, even if not a first choice college. Some new exploratory work in this area suggests, however, that rationing may have a role; that the supply of education may constrain the subsequent supply of educated labor. A thoroughgoing analysis of rationing requires a simultaneous equations model of the supply and demand for education. That is not undertaken here.[1] But a rationing variable, along with a non-market quality of schooling variable, is used in the equations for the supply of college educated labor.

---

[1]See McPherson (1974) for such a model.

Both non-market school quality and rationing are difficult to measure. Indicators proposed for the quality of schooling include expenditures per student, faculty salaries, aptitude test scores of entering freshmen, selectivity of admissions, and composite ratings (partly subjective).[1] The merit of one indicator relative to another is not easily judged. But intercorrelation between the various quality measures is usually quite high.[2] Three alternative indicators are used in this study. One is the acceptance rate of applications for admission to colleges and universities. This data was available for 1966. Its correlation with average SAT scores of entering freshmen is high, r = .88 (Astin 1966). Second, private college enrollment as a share of total enrollment may reflect school quality since it is sometimes thought that private colleges provide the amenities which constitute non-market quality. Third, non-market quality is indicated by a measure of "attractiveness" of a state's higher education system developed and quantified by Gossman (1968, Ch. 12). The attractiveness index is a paramenter of a gravity model for student migration between states. It measures the attractive force which one state has for students in other states. It depends on the absolute flow of student inmigration to a state, the distance from other states, and the outmigration potential from other states. Because this

---

[1]The Gourman Report is an example of the latter.

[2]See the study by Solmon in Solmon and Taubman (1973).

measure of the attraction which a state's schools have for out-of-state students takes into account proximity to sources of students, it may indicate the non-market quality of the state's schools.

To obtain an indicator for rationing, Gossman can again be used. There is no direct measure of rationing, but the evidence in Gossman (Ch. 10) is that the outmigration rate of college students is related to rationing. The outmigration rate is calculated as the number of students who leave their home state to go to college divided by the total number of residents of the state who are college students, both outmigrants and non-migrants. The outmigration rate becomes an indicator for rationing when it is used in a regression equation containing both the market return to college and the non-market quality of schooling. When these variables are held constant, outmigration of students reflects the effects of forced exits, or rationing, on the state's supply of college educated labor.

The absolute price level. An undesired source of variation across states in the earnings and family income data is differences in the absolute price level. The analysis should be conducted in real rather than nominal terms. There is no published data on cost of living indexes by states. But there is cost of living data, which is comparable over space, for 40 metropolitan areas and for four non-metropolitan regions from the Bureau of Labor Statistics (see Appendix I). There is additional cost of living index data for 154 cities from the American Chamber of Commerce Research Association. All of this data was used to construct an index for the absolute price level for each state for 1970. All dollar-denominated variables entering the supply equation were deflated by this index.

The Estimating Equation and the Hypotheses

Two basic supply equations for college educated labor were estimated. The equation for the age group 25-34 years is:

$$\ln L_1^* = a_0 + a_1 \ln BEN + a_2 \ln COST + a_3 \ln HS + a_4 \ln Y$$

$$+ a_5 \ln LOAN + a_6 \ln Q + u \qquad (30)$$

where L_1^* = the share of white males with income age 25-34 who have 16 or more years of school completed in 1970[1]

$BEN = (W_i - W_j)\left[\frac{1}{r} - \sum_{t=1}^{m} \frac{1}{(1+r)^t}\right](1-\rho)$ = median annual income of college minus high school educated white males age 25 or more years in 1960 $(W_i - W_j)$, cumulated over the working life and discounted back to the college decision year, and multiplied by the probability of getting the benefit stream (where ρ = the involuntary drop-out rate)

---

[1]Because the size of states of the U. S. varies greatly, the absolute number of college educated workers is scaled by the size of the relevant population. Since the data on years of school completed refer to adult males with income, we may speak of this as labor force data for all practical purposes.

$$COST = \sum_{t=1}^{m} \frac{W_j' - W_i^{pt} + DC_i}{(1+r)^t} \cdot (1-\rho) = \text{net fore-}$$

gone earnings W_j', which is median annual income of high School educated workers age 18-24 in 1960; minus average part-time income of college students in 1960; and direct costs, which is revenues from tuition and fees minus scholarship aid plus revenues from room and board per student in all public and private four year institutions of higher education. The costs are cumulated for the m years of college and discounted back to the decision year, and, as for BEN, are multiplied by the probability they will all be incurred.

HS = the number of new high school graduates in 1960 as a percent of the population age 18

Y = median annual income of husband-wife families whose head of household is age 35-54 and who have children age 18 or under in 1960

LOAN = government loan funds disbursed by four year institutions of higher education per enrolled student in 1966

Q = the quality of schooling, indicated by the acceptance rate among four year institutions of higher education, or alternatively by the Gossman "attractive" index.

The second basic equation is for the age group 25+ years. It differs from equation (30) in its empirical specification only insofar as the dependent quantity variable changes from the level variable L_i^* to the rate of change variable ΔL_i, where ΔL_i indicates the change from 1960 to 1970 in the share of college educated white male workers age 25+ in the labor force who have 16 or more years of school completed.

Both data on years of school completed and income by years of school completed come from the U. S. Census of

Population, 1960 and 1970.[1]

Four variations of these basic supply equations are estimated.

(1) An alternative hypothesis about how prospective students determine the benefit of education is tested. This hypothesis says that prospective students predict the future earnings of college and high school educated workers rather than use their current earnings (p. 16). When this hypothesis is invoked, W_i and W_j in the benefit term are defined as above, but measured in 1970 rather than 1960. The cost term is unchanged, but of course a new net return term is obtained.

(2) An experiment is conducted with a different indicator for quality of schooling coupled with the introduction of rationing of places as a possible supply constraint. The new quality indicator is the Gossman "attractive" index, and the rationing indicator, RATION, is the student outmigration rate in 1963 (see pp. 77-80).

(3) The potential effects of geographic mobility of workers on the supply model are introduced. First, the supply equations are estimated with observed net interstate

---

[1]The indicator for the number of leavers from educated labor category L_i (L^o_{it}) was not used in equation (30). Not only is the total number of college educated workers age 55 years or more in 1960 an imperfect indicator for the number of deaths of such workers between 1960 and 1970, but also the number of such workers was small in 1960, so that most of the change in L_i between 1960 and 1970 must be accounted for by entrants rather than by leavers.

migration of college educated workers taken out of the dependent variable L_i^* or ΔL_i in order to return to the no-mobility model (see pp. 38-40). Second, the hypotheses that prospective college students are aware of some probability of outmigration from their home state for employment in another state are introduced. Under the regional migration hypothesis, a new benefit term is calculated which includes not only the home state benefit, but also the benefit of a college education in other states and the probabilities of migration to those states (see pp. 41-43). Also, the hypothesis that there is a national market for college educated labor is tested. Under this hypothesis, the same national college earnings figure is available to all college graduates (see pp. 44-45).

(4) Two alternative functional forms of the supply equation are estimated, since there is little theoretical basis for choosing one form over another. First, the supply equation is estimated as a linear equation without making the logarithmic transformation. Second, the benefit and cost of education terms are combined into a single net return term, NR, in a log-linear specification. Evidence can thus be provided on the sensitivity of the estimated coefficients to the functional form specified. The original log-linear specification $\ln L_i^* = a_1 \ln BEN + a_2 \ln COST + \ldots$ of equation (30) is a different functional form from the alternative log-linear specification $\ln L_i^* = a \ln NR + \ldots$, just as is the specification $L_i^* = c\ NR + \ldots$,

without the logarithmic transformation. Each specification implies different relationships among the coefficients a_1, a_2, a, and c. Since NR = BEN - COST, the specification $L_i^* = c\ NR + \ldots$ is equivalent to $L_i^* = c\ BEN - c\ COST + \ldots$, i.e., the estimated coefficients of BEN and COST should be equal (but of opposite sign) and the coefficient of NR (estimated in a separate equation) equal to that of BEN, when the supply equation is linear. If the alternative log-linear functional form $\ln L_i^* = a \ln NR + \ldots$ is used and subsequently NR is broken down into BEN and COST, the resulting equivalent specification is $\ln L_i^* = a \ln BEN + a \ln (1 - \frac{COST}{BEN}) + \ldots$,[1] which is clearly not the same as the original $\ln L_i^* = a_1 \ln BEN + a_2 \ln COST + \ldots$. In the alternative log-linear equation, the coefficient of NR and BEN estimated in separate but functionally equivalent equations should be equal, and no effect of COST by itself is estimated. In the original log-linear equation, the estimated coefficients of BEN and COST need not be equal, and no equivalent estimate for the effect of NR is obtained.

Usually in a structural supply equation containing both a wage variable on the right hand side and a dependent quantity variable, one would expect the wage variable to be endogenous because of the simultaneous determination of wages and quantities by both supply and demand forces.

---

[1]Since $\ln L_i^* = a \ln NR$ implies $L_i^* = NR^a$, and NR = BEN - COST may be expressed as $BEN(1 - \frac{COST}{BEN})$, we obtain $L_i^* = BEN^a (1 - \frac{COST}{BEN})^a$, or $\ln L_i^* = a \ln BEN + a \ln (1 - \frac{COST}{BEN}) + \ldots$.

Therefore, the ordinary least squares estimator of the wage coefficient would be biased and inconsistent. An alternative estimation procedure, such as indirect least squares, would be required to obtain consistent estimators. In equation (30), however, there is no separate wage variable, although the level of earnings of college educated labor is contained as one of four variables in the BEN term and as one of seven variables in the NR term. But these other components of BEN and NR are affected little if at all by the number of college educated workers. Furthermore, in equation (30), the explanatory variable NR is lagged and therefore predetermined. NR is measured in 1960 while L_i^* is measured in 1970. L_i^* cannot logically be a cause of NR and is therefore endogenous. The same relationship applies for Y. Therefore it seems from a priori considerations that neither BEN nor NR are endogenous and that ordinary least squares estimation could be appropriate.

Two states, New Hampshire and Vermont, were deleted from the analysis (following Peltzman 1973) because a large share of the college students in those two states were not residents of the state. If a student leaves his home state to go to college and then returns to his home state for employment, the relation between a state's college benefits and costs and its stock of college educated labor will be misrepresented. (If a student goes to college out of state and remains out of state, there is no problem.) On the average 83 percent of a state's college and graduate students are residents[1] so the extent of gross student mobility is not arithmetically large and may not be empirically important. Also, the correction for net interstate migration will reduce the effect of student mobility. West Virginia was deleted because its level and rate of change of educational attainment are far below that of any other state. Its economic and social history as well as present conditions are unusual, and render the explanation of educational attainment in its case different from that of the other states.

Results of the estimation of the equations for the supply of college educated white males are given first for age group 25-34 years in Tables 3, 4, and 5. Table 3 presents results from equation (30) for (1) the basic benefit hypothesis ("current") under which prospective students use current earnings data available at the time the education decision is made to evaluate the expected benefit from education, and (2) the alternative benefit hypothesis ("predicted") under which prospective students predict future earnings to determine their benefit from education.

Table 4 presents the results of estimating two different functional forms of the supply equation: a log-linear equation in which a net return variable is used instead of the benefit and cost variables separately; and a linear supply equation, without the logarithmic transformation.

---

[1]See the special study by the U. S. National Center for Educational Statistics (1968).

Table 5 presents the results of taking geographic mobility of workers into account. In Panel A a crude correction for interstate migration of college educated workers is applied to the dependent variable. In Panel B regional migration hypotheses are tested, under which prospective students incorporate knowledge of the probabilities of outmigration from their home state to other states for employment to determine their benefit from education. In Panel C the hypothesis is tested that there is a national labor market for college educated workers, with U. S. average $\overline{W}_1$ in each state's benefit term.

The Benefits and Costs of College Education

The results of the estimation of the supply model in Tables 3-5 are consistent with theoretical expectations and observed labor market behavior. They suggest that the investment theory of education is important in explaining the college education decision of white males. The regression coefficients have the expected sign and are of reasonable magnitude. The effect of the economic benefit of college education on the stock of college educated labor is positive and significant, and the effect of the cost of investing in college education is negative and significant. The supply curve shift variables attain a high degree of statistical significance in at least some of the equations, although not all coefficients are precisely estimated in all equations. The R^2 values are moderate to high. Experiments with various migration hypotheses, functional forms, and data adjustments confirm these results. The conclusions reached are robust.

The elasticity of supply of young college educated white males with respect to the economic benefit of college education is estimated to be .297 (Table 3). This is the value for the coefficient of BEN (since the supply equation is estimated in logarithms the coefficients refer to percentage changes). It is precisely estimated but a modest number arithmetically. Changes in the benefit of college education produce modest changes in the subsequent supply of young college educated white males. But the effect of changes in <u>earnings</u>, W_i or W_j, operating via BEN, is substantial. This is because a large change in BEN is produced by a small change in either W_i or W_j. This finding is of first importance: Substantial changes in the supply of young college educated white males result from small changes in earnings difference between college and high school educated workers.

For example, a $73 increase in W_i (one percent of its mean in 1960) brings about a four and one-half percent increase in BEN. Thus a one percent increase in W_i, when translated through BEN, brings about a 1.3 percent increase in L_i^*. The college education decision is sensitive to the earnings of college educated workers.

The magnitude of these changes can be illustrated

TABLE 3. Estimated regression coefficients for the supply of college educated white males age 25-34, states of the U. S., 1970

Right-hand side variable (logs)	Benefit Hypothesis[a]	
	Current	Predicted
BEN	.297*** (.095)	.231*** (.086)
COST	-.727*** (.205)	-.690*** (.210)
HS	.466*** (.125)	.491*** (.132)
Y	.476* (.332)	.604* (.329)
LOAN	.180** (.085)	.145** (.085)
Q	-.223** (.091)	-.258*** (.092)
constant	.379 (2.851)	.391 (2.879)
R^2	.597	.574

NOTES:
The dependent variable is ln L_i^*.
See p. 83 for an explanation of the benefit hypothesis.
Standard errors in parentheses below estimated regression coefficients.
*, **, *** = statistical significance exceeding the .10, .05, and .01 levels, respectively, for a one-tailed test.

using data on the U. S. mean values of these variables. If the earnings of white college educated men had been just 10 percent higher in 1960, then the share of college educated white males age 25-34 in 1970 would have been 23.2 percent instead of the actual 20.5 percent (other supply determinants constant). But if the wages of college graduates had been 10 percent lower in 1960, this group would have accounted for only 17.1 percent of the labor force. In absolute terms, a change of 10 percent in the earnings of white college educated men would have meant a change of about 32,000 students each year of the 1960-1970 period in order to arrive at the 1970 stock predicted by the higher (or lower) earnings than actually prevailed. This would have required about 65 more (or fewer) average-size colleges. or about six new (or fewer) large (20,000 students) state universities, or more than (less than) an entire University of California system.

The effect of changes in the earnings of high school educated workers can also be illustrated. A one percent increase in the earnings of white high school educated men reduces BEN by about three percent and, via the coefficient of BEN, L_i^* would fall by nearly .9 percent. If also the earnings of <u>young</u> high school educated white men (the foregone earnings cost of college attendance) increased one percent, COST would increase .8 percent. A further reduction in L_i^* of .6 percent would occur via the coefficient of

COST, giving a total negative effect of 1.5 percent on L_i^*. Thus the impact of the earnings of high school educated workers, which is felt via both the benefits and costs of a college education, is slightly larger in total (1.5 percent) than the impact of the earnings of college educated workers (1.3 percent).

The coefficient of COST is -.727 (Table 3). This suggests the supply of young white college educated men is responsive to changes in the cost of a college education, but less than unitary elastic. This result is consistent with the findings of studies in the demand for college enrollment.[1]

In 1960 the average value of COST was $7,560. Had COST been 10 percent lower in 1960 than it was, the 1970 stock of young white college educated men would have been 22.0 percent rather than 20.5 percent. Note that the coefficient of COST (-.727) is greater in magnitude than the coefficient of BEN (.297). But the effect of COST on L_i^* is weaker than the effect of W_i operating through BEN. A 10 percent increase in W_i would have raised L_i^* from 19.7 to 23.2 percent, while a 10 percent decrease in COST would have raised L_i^* to 22.0 percent.

The fact that the coefficient of BEN is smaller in absolute value than the coefficient of COST suggests that

---

[1]For example, Campbell and Siegel (1966) estimated the tuition elasticity of demand for enrollment to be -.440. On the other hand, Hopkins (1971) got a negative but not statistically significant tuition elasticity.

prospective college students are more responsive to changes in the cost of a college education than to changes in its benefits. But on a priori grounds it might be expected that the benefit and the cost of a college education should have equal effects.[1] A given dollar change in the benefit, with costs constant, affects the net return the same as an equal dollar change in the costs, given the benefit. But in fact the estimated coefficient of BEN is less than the estimated coefficient of COST in Table 3. Are these estimated coefficients correct? If so, why are they different?

If these coefficients are correct, it means that BEN would have to increase faster than COST in order to account for an increase in L_1^*, since the coefficient of BEN is smaller than that of COST. Indeed, BEN would have to increase faster in percentage terms (since the supply equation in Table 3 is estimated in logarithms). From the U. S. time trend data reported on pages 19 and 22, it appears that the percentage increase in BEN has slightly exceeded the percentage increase in COST.[2] But this difference may not be enough to permit the supply equation to account for the observed increase in the supply of college educated

[1]The estimating equation does not mathematically require equal coefficients, however. See p. 83.

[2]This implies a slight increase in the rate of return over time. Note that the U. S. state average of rates of return was higher in 1970 than 1960 (using consistent methodology [see Appendix III]). Previous studies suggest that the rate of return to a college education investment has, at least until 1970, not fallen. (See Appendix II.)

white males over time. Therefore a statistical test was made to ascertain if the coefficients of BEN and COST were significantly different. This required estimating an equation in which they were constrained to be equal (which is the untransformed equation containing NR, in Table 4, following) compared to that in which they were free to vary from each other. The F test showed that the null hypothesis that the coefficients were equal could not be rejected at the .01 level, but it was rejected at the .05 level. This leaves the matter unsettled. Three explanations which could account for different coefficient values are offered.

The first is simply that BEN is measured with error, which biases its coefficient downward. The calculation of BEN as well as the data itself are sources of error. Second, changes in COST affect both the investment and consumption demands for education, but only the investment demand is affected by changes in BEN. As long as the consumption demand is non-zero, the coefficient of COST would on this account exceed that of BEN. Third, students' determination of BEN may be different from its actual future value. BEN and COST, as decision variables, are in fact quite different in nature. The costs of college, both foregone earnings and out-of-pocket direct costs such as tuition, are immediate and well-known. In contrast the benefits are distant and uncertain. While they can be mathematically expressed, ex post, in present value terms, they are only received in the future and with uncertainty. It seems likely that the prospective college student would have a smaller regard for measured changes in the benefit of a college education than he would for equal measured changes in the cost. Perhaps changes in the measured benefit are subjectively discounted for uncertainty since that benefit may not be received. Fewer men act on changes in the benefit, compared to equal changes in the cost, because the substantial commitment of time and money which that action entails may not be rewarded to exactly the extent which the measured change in the benefit predicts. In any event, prospective students have only current information to use in determining the future benefits. They may make errors in determining it.

Empirical Experiments

Three experiments were conducted to ensure that the results are not artifacts, but rather are robust with respect to the empirical formulation used.

Correction of benefit term for experience. Because length of experience in the labor force positively affects earnings, it may have an effect on the measured benefit term. This effect should be eliminated since the average experience level in a state is not relevant to the prospective college student's determination of his benefit from college education. To do this one should ideally know exactly how much earnings change for each year of labor force experience. In the absence of data to make such a calculation for each state of the U. S. in 1960, information on the age composition of college and high school educated workers was used to adjust BEN. If college educated workers are young relative to high school educated workers, then BEN is understated because median W_i is understated relative to median W_j, and conversely. Thus BEN was multiplied by the ratio $\frac{L_i^*}{L_i} / \frac{L_j^*}{L_j}$. The results of this adjustment were to slightly increase the coefficient of BEN and slightly decrease the coefficient of COST. Thus the adjustment has a favorable effect on the estimation of the supply equation, but it is very small. Because of the arbitrary nature of the adjustment, it will not be further used.

<u>Alternative indicators for W_i, W_j</u>. The indicator for W_i and W_j is median annual income, which includes income from all sources (perhaps even inherited property income). The optimum indicator, which is not available, is earnings associated with education. To test the sensitivity of the BEN and NR coefficients to the indicator for W_i and W_j, an adjustment was made to approximate rate of pay rather than annual income. Thus the two extremes of the W_i, W_j measures are used. This was done using data on unemployment and part-time working for college and high school educated workers. Areas of high unemployment and high part-time working would tend to have low annual income, but not necessarily low rates of pay, and conversely. Thus W_i and W_j were separately adjusted for these two variables. The

results were very small downward changes in the coefficients of BEN and COST. Thus the necessity of using an empirically less-than-perfect indicator for W_i and W_j does not appear to materially affect the results of the estimation of the supply equation.[1]

The discount rate. The calculation of BEN is sensitive to the discount rate used. Although the specification of r is theoretically sound, its empirical formulation has elements of arbitrariness. A test was made of the extent to which the value of r used for each state affected the estimation of the supply equations by re-estimating them under the extreme assumption that r was equal and constant for every state. The results were only very slight changes in the BEN and COST coefficients. The coefficient of BEN fell from .297 (Table 3) to .275 (and retained high statistical significance) when r was taken to be constant. The coefficient of COST increased by a small amount, from -.727 to -.779. Taking different constant values for r both below and above the mean r, did not affect these results. The coefficient of Y, however, rose from .476 to .854. But the income elasticity is still less than unity. None of the other coefficients of R^2 was affected by the use of a constant r.

---

[1]Of course, the magnitude of unemployment and part-time working for college and high school educated white males is small, and the variation across states is also not large.

The Predicted Earnings Benefit Hypothesis

The second column in Table 3 shows the results of the estimation of the supply equation when an alternative hypothesis about how prospective college students determine the benefit to college education is used. Under this hypothesis, students make predictions of the difference between the earnings of college and high school educated labor in the future. Under the original hypothesis, students reckoned the earnings difference of men with several years of labor market experience at the current time, in the college decision year. Under the alternative hypothesis, BEN is calculated using 1970 rather than 1960 earnings data. The result is that the coefficient of BEN (.231) is smaller when calculated using future earnings data. Two conclusions are possible: (1) Students do not make predictions of future earnings differences to determine their benefit from a college education to the same extent they use current earnings information, or (2) If they make predictions, they systematically underestimate the size of the benefit stream. If the latter is true, it may be due to the secular increase over time in the difference between the earnings of college and high school educated labor, which prospective students may not anticipate. The predicted earnings benefit hypothesis imposes a more sophisticated view of the prospective student's decision process than may be warranted.

Supply Curve Shift Variables

High School Graduates

Marginal increases in the number of high school graduates produce proportionally smaller increases in the stock of young white college educated men. The size of the population eligible to go to college is apparently not a binding constraint on the number of male college students. Few of the extra high school graduates would go on to college anyway.

The coefficient of HS (the share of new male high school graduates out of the male population age 18) is .466 (Table 3, column 1). This implies that the marginal continuation rate from high school through college is less than the average continuation rate. In 1960 about one-third of high school graduates went on to college. If the number (share) of high school graduates increased by one percent, the stock of college educated labor would increase also by one percent, if the same fraction, one-third, went on to college. In this case the coefficient of HS would be 1.0. In fact it is less than half that size, which means that the marginal continuation rate is also less than half as large as the average continuation rate of one-third. Thus only one-sixth, at most, of the extra high school graduates would be expected to subsequently appear in the stock of college educated white males. Since the number of high school graduates as a share of the population was about 80 percent (U. S. average in 1960), it is not surprising that changes in this figure would have little effect on the stock of college educated labor.

Ability to Pay

There are two ability-to-pay variables in the supply of educated labor equations: Y, a family income variable, and LOAN, which is government loan aid per student. Both have significant positive effects on L_1^* (Table 3, column 1). The effect of Y is much larger, which may be due to the fact that family income is a much more important source of meeting college expenses.[1] It may also be due to an additional effect which Y but not LOAN is hypothesized to pick up, which is the demand for education as a consumption good.

The supply of young white college educated men is income inelastic. This result sheds light on the question of the income elasticity of demand for college education. The common belief is that college attendance is income elastic--that modest percentage increases in family income produce large percentage increases in college enrollment. Some previous studies have found the income elasticity of demand for college to be elastic (e.g., Campbell and Siegel estimated the income elasticity of demand for college to be 1.2). Other studies have estimated the effect of income to be positive but inelastic. The empirical results of this

[1] According to Lansing (1962), 60 percent of all college expenses were paid for out of family income in 1960, while government loans could not have been more than 8 percent.

study provide strong evidence that the income elasticity of demand for college education is not elastic. The reason for previous elastic estimates probably stems from specification errors. When the model in this study is purposely misspecified by omitting the variables for the economic benefit of college and the foregone earnings cost of college, then the estimated income coefficient changes from inelastic to elastic. These variables have in fact been left out of other studies in the demand for college education. Perhaps this accounts for the conflicting and erroneous estimates previously reported.

The effect of making funds available to help college students pay for their education via government loans is not as strong as the effect of reducing those costs directly. Since government loans are a policy variable, it is important to know the magnitude of the consequences from changing loan policies. According to the estimated coefficient of LOAN in Table 3 (.180) marginal changes in LOAN have small effects on the supply of young white college educated men. If LOAN had been 10 percent higher in 1960, L_i^* in 1970 would have been 20 percent rather than 19.7 percent. To get a one percentage point increase in L_i^* would have required an increase of nearly one-third in LOAN. Such changes are not marginal changes, and no such predictions can properly be made from these regression coefficients. Recall, however, that loan programs were quite new and small-scale in 1960. Substantially different results may be true today.

Quality of Schooling and
Rationing of Places

The non-market dimension of the quality of schooling has a modest but significant effect on the supply of young white college educated men. The indicator, Q, is the acceptance rate of applications for admission to colleges and universities. Its coefficient, -.223, is negative. This is the correct sign since higher quality of schooling is indicated by a lower acceptance rate. The lower the value of Q, the higher the quality of schooling, and, according to the estimated coefficient, the larger the supply of young white college educated men, given the benefits and costs of schooling.

The non-market quality of schooling is not uniquely defined. It may be measured in different ways. For example, a low college acceptance rate (the Q in Table 3) may reflect the extent of private as opposed to public higher education in a state, since public institutions are often committed to accepting all qualified applicants. In fact it is sometimes thought that private colleges provide the kind of amenities which a non-market quality indicator should represent. If this is true, private enrollment as a share of total enrollment can be used directly as a schooling quality indicator. The use of a private enrollment indicator constitutes a test of a specific non-market quality hypothesis;

specifically, that the larger the private enrollment, the higher the non-market quality, and the larger the subsequent stock of college educated labor. The result of this test was that private enrollment, as a dimension of school quality, has the expected effect, but it is very small (the coefficient was .037). Attributing special qualities to private higher education and not to public would not seem warranted. The use of the Gossman attractiveness index as a school quality variable also yielded only a small effect. Perhaps more important for this analysis, the coefficients of the other variables in the supply equation were affected very little by the change in the quality indicator. This gives confidence that the estimated effects of the benefits and costs of college on the stock of college educated labor are robust with respect to specification of the school quality.

While high quality education encourages college attendance, it may at the same time result in rationing of places. High quality may come at the expense of places since resources can be used to purchase either quality or quantity but perhaps not both. It therefore is desirable to include rationing, which is expected to have a negative effect on the stock of college educated labor, along with the quality of schooling in the supply equation. Once the quality of education is controlled, rationing may be indicated by out-migration of college students to other states.

The following equation was estimated with the rationing indicator (all variables in logs):

$$L_i^* = 2.056 + \underset{(.097)}{.293}\ BEN - \underset{(.207)}{.725}\ COST + \underset{(.128)}{.460}\ HS + \underset{(.339)}{.464}\ Y$$

$$+ \underset{(.090)}{.174}\ LOAN - \underset{(.099)}{.213}\ Q - \underset{(.047)}{.012}\ RATION \qquad R^2 = .610 \qquad (31)$$

While RATION enters the equation with the expected minus sign, the coefficient is small and not significant. Thus rationing as here measured has little effect on the subsequent stock of college educated workers.[1] None of the other coefficients is affected by the inclusion of the rationing indicator. Because of no effects of rationing no further experiments with rationing will be done in the supply equation work.

Functional Form

To test the sensitivity of the estimated relationships to the functional form of the supply equation, the original equation in Table 3 was estimated as a linear equation in the untransformed values of the variables (Table 4). The results are that the same interpretations are made from either the linear or the log-linear equation and thus that the supply relationships are not sensitive to the functional form of the supply equation. For example, a 10 percent ($1,960) change in BEN produces a 2.97 percent change in L_i^* (from the log-linear equation in Table 3), which amounts to a .586 percentage point change in L_i^*, figured from the mean. The same initial $1,960

[1]McPherson (1974) finds that rationing at public institutions has effects on relative public and private enrollments but not on total enrollment.

TABLE 4. Estimated regression coefficients for the supply of college educated white males, age 25-34, using alternative functional forms, states of the U. S., 1970

Right-hand side variable	Functional Form[a]		
	Linear		Log-Linear
NR		.00028** (.00013)	.114*** (.046)
BEN	.00029** (.00012)		
COST	-.00182*** (.00065)		
HS	.10281*** (.03351)	.09726***	.464*** (.137)
Y	.00142 (.00099)	.00111 (.00104)	.255 (.369)
LOAN	.02027 (.01799)	.01871 (.01907)	.112 (.089)
Q	-.06951** (.03268)	-.02653 (.02916)	-.085 (.086)
constant	11.91680* (7.52310)	2.26820 (6.77140)	-2.446 (2.908)
R^2	.540	.469	.509

NOTES:

[a]See page 84.

Right-hand side variables are in natural logarithms for the log-linear functional form and in untransformed values for the linear functional form.

The dependent variable is ln L_i^* for the log-linear functional form and L_i' for the linear functional form.

Standard errors in parentheses below coefficient estimates.

*, **, *** = statistical significance exceeding the .10, .05, and .01 levels, respectively, for a one-tailed test.

change in BEN produces, via the coefficient of BEN (.00029) in the linear equation of Table 4, a .588 percentage point change in L_i^*. Similarly, equal 10 percent changes in COST yield a 1.432 percentage point change in L_i^* when using a log-linear supply equation, and a 1.368 percentage point change in L_i^* when using the untransformed linear model.

Recall that the estimated coefficient of BEN in the linear specification $L_i^* = c$ BEN - c COST + ... should mathematically be equal to the estimated coefficient of NR (the net return) in the equivalent specification $L_i^* = c$ NR + ... (see p. 84).[1] Changes in the net return should have the same effect on the college education decision as changes in the gross return when costs are constant. This expected equality was tested and confirmed. The coefficient of NR was estimated to be .00028 (Table 3, column 2) which is nearly identical to the estimate of .00029 for the coefficient of BEN. This result provides further evidence that the conclusions drawn about the effects of the economic benefit of college on the future supply of college educated labor are both valid and reliable.

A third functional form was also specified, in which BEN and COST in the original log-linear equation were

---

[1]The estimated coefficients of BEN and COST in the linear specification should also be equal (and of opposite sign). They are not in fact equal, since the coefficient of BEN is .00029 while the coefficient of COST is -.00182 (Table 4, column 1). This disparity was also observed in the log-linear specification (Table 3, column 1), and explanations were offered there for its occurrence.

replaced by NR alone in a new log-linear equation (see p. 84). In this case, unlike the linear case, there is no mathematical expectation that the coefficient of NR should be equal to that of BEN because each is estimated from a functionally different log-linear equation. In fact, *a priori* reasoning suggests that the coefficient of BEN should be larger than that of NR. Since BEN is much larger than NR in absolute terms, equal percentage changes in each mean larger absolute dollar changes in BEN than in NR. A one percent change in BEN will have a greater effect than a one percent change in NR on L_i^* because that one percent change represents a greater dollar change in the economic return to a college education. This relationship was in fact observed when the log-linear equation containing NR rather than BEN and COST was estimated ($\ln L_i^* = a \ln NR + \ldots$). The coefficient of NR was .114 (Table 4, column 3), while the coefficient of BEN previously estimated (Table 3, column 1) was .297.

It is possible, using the third functional form, to obtain an equation incorporating BEN and COST which is functionally equivalent to the equation containing NR. That is, $\ln L_i^* = a \ln NR + \ldots$ is equivalent to $\ln L_i = a \ln BEN + a \ln (1 - \frac{COST}{BEN}) + \ldots$ (see p. 84). Here the estimated coefficients of NR and BEN should be equal. However, when the latter equation was estimated, the coefficient of BEN was not significantly different from zero, whereas the coefficient of NR from the same functional form was .114. Furthermore the coefficient of $(1 - \frac{COST}{BEN})$ was estimated to be .161, which is not equal to either the coefficients of BEN or NR, although it should be. Therefore it seems likely that the third functional form is inappropriate. Because of this reason and because of the unavailability of a separate COST variable in this specification, it will not be further used.

The Effects of Migration

Correction of L_1 for net migration. Theoretically the net return to a college education in a state determines the supply of college educated labor in the state by influencing how many high school graduates obtain a college education. But empirically the number of college educated workers in a state is increased by net inmigration and decreased by net outmigration. Presumably there is net inmigration of college educated workers to states where their earnings are high and net outmigration where their earnings are low. Since the benefit of college education would also tend to be high in these states, BEN will reflect net migration as well as investment in college education by indigenous non-mobile workers. Therefore a correction should be made for these net interstate flows of workers to obtain an unbiased estimate of the effect of the benefit and cost of a college education in that state on the stock of college educated labor in that state.

The correction is quantitatively quite small since net migration is quite small, although gross geographic mobility of college educated workers is high. For example, the average absolute value of net interstate migration for the contiguous states over the 10 year span from 1960 to 1970 was 4.5 percent for the white population (excepting Nevada and Florida, where net migration was 52 and 33 percent, respectively). Total interstate migration for all males age 25 years or older in the single year 1965 was 2.6 percent, and for college educated males, 4.9 percent. The only net migration data available by states of the U. S. is from the 1960 Census of Population, by sex and age, but not by years of school completed, for the time period 1955-60. Subsequent U. S. aggregate data on net migration was used to check trends over time and make adjustments in the few cases where there were clear slowdowns in net migration. These data are not ideal since their use requires the implicit assumption that college educated workers have the same net migration rate as the average workers.

When the effects of net migration are removed from L_i^*, the coefficient of BEN is slightly reduced, from .297 (Table 3) to .275 (Table 5, Panel A). This is expected since in the absence of the correction, the BEN variable picks up some of the net migration effect. When net migration is taken out, a smaller and more correct value for BEN results. Likewise, a somewhat smaller coefficient of COST is obtained, from -.721 (Table 3) to -.671 (Table 5, Panel A). The effect of family income on L_i^* also drops somewhat when net migration is corrected. Since there is a positive relation between family income and earnings of college educated workers, there is a tendency to net in-migration in high income states, which means that Y picks up some of the net migration effect.

Regional migration. Prospective college students may be aware of the probabilities of outmigration from their home state for employment out-of-state after they graduate. On the average about 7.1 percent of young college educated white men leave their home state in a single year;[1] a large majority of this migration occurs between neighboring states in the same region. Regional migration can be dealt with by reformulating the benefit of college education. The hypothesis is that prospective college students use out-of-state earnings differences as well as home-state earnings differences to determine their benefit of a college education. Data on actual outmigration flows from state of origin to states of destination were used to weight out-of-state W_i-W_j with home-state W_i-W_j to give a regional benefit of college education.

The estimation of the supply model under the regional benefit hypothesis gives results that are not materially different from the basic no-migration model

[1]Calculated for the 1955-60 period from U. S. Census of Population data. Outmigration for college educated white males is 1.4 times greater than all white males.

(Table 5, Panel B). The coefficient of BEN is slightly higher (.308 vs. .297). This suggests that prospective college students consider outmigration only to a limited extent when determining their college benefit. They may be unaware of migration probabilities or migration may be determined by factors other than earnings. If out-of-state earnings differences are not relevant to the migration decision, they may not enter the prospective student's college decision.[1] An alternative explanation is simply that the home-state benefit dominates the out-of-state benefit due to the quite small probabilities of outmigration, and thus the coefficient of BEN is only marginally affected.[2]

A national labor market for college educated workers. It is possible that there is sufficient interstate migration of college educated workers in response to interstate earnings differences that there is a national labor market for these workers and a single national wage. Then the prospective college student in any state may use the national $\overline{W}_1$ instead of his state W_1 to determine his benefit from college education. To test this hypothesis, BEN was

[1]Not all states of destination for outmigrants have a higher benefit than the home state. Thus the effect of outmigration on the overall benefit is not large in general.

[2]Recall that we deal here not with the extent of interstate migration by college educated workers over their lifetime, which is quite high; rather, we require the probability of outmigration in a single year, after graduation from college.

reformulated using $\overline{W}_i - W_j$ as the earnings difference component, where $\overline{W}_i$ is the U. S. aggregate median income of college educated white males and W_j remains the state figure.[1]

The results of the estimation of the supply model under the assumption of a national labor market for college educated white males are that the coefficient of BENNAT (BEN under the national labor market hypothesis) is somewhat lower and less precisely estimated than in the basic no-mobility model (Table 5, Panel C, column 2). Nevertheless, the coefficient remains sizable and statistically significant.

Two interpretations are possible. One is that a national market for college educated labor is less applicable than a local or state labor market since the economic return to education specified under the national market hypothesis has a weaker effect on the supply of college educated labor. The alternative interpretation is that the national market hypothesis is correct and that the coefficient of BENNAT is simply its true effect on subsequent L_i^*. (Note that the difference is not great, and that the investment theory of education is supported in either case.)

A test can be made to distinguish between these two interpretations. Both BEN and BENNAT are entered in the supply equation simultaneously so that the regression

[1]Since high school educated workers exhibit much less mobility, it is assumed there remain local (state) labor markets for them.

TABLE 5. **Estimated regression coefficients for the supply of college educated white males age 25-34 when there is geographic mobility, states of the U. S., 1970**

Right-hand side variable (logs)	A Benefit Hypothesis[a]		B Regional Migration Benefit Hypotheses[a]		C National Labor Market Benefit Hypothesis[a]	
	Current	Predicted	L_i, L_j Migrate	L_i Only Migrates		
BEN	.275*** (.095)	.189** (.087)				.244** (.106)
BENREG			.308*** (.099)	.294*** (.099)		
BENNAT					.174* (.113)	.015 (.127)
COST	-.671*** (.204)	-.611*** (.212)	-.725*** (.205)	-.709*** (.206)	-.601*** (.214)	-.760*** (.215)
HS	.471*** (.125)	.483*** (.133)	.456*** (.125)	.455*** (.126)	.454*** (.138)	.453*** (.130)
Y	.270 (.331)	.431* (.332)	.458* (.336)	.522* (.331)	.883*** (.306)	.472* (.341)
LOAN	.202** (.085)	.163** (.086)	.181* (.086)	.176** (.086)	.109* (.085)	.181** (.087)

TABLE 5.--Continued

Right-hand side variable (logs)	A Benefit Hypothesis[a]		B Regional Migration Benefit Hypotheses[a]		C National Labor Market Benefit Hypothesis[a]	
	Current	Predicted	L_i, L_j Migrate	L_i Only Migrates		
Q	-.219** (.091)	-.254*** (.093)	-.214** (.092)	-.223** (.092)	-.331*** (.097)	-.245*** (.100)
constant	1.787 (2.835)	.810 (2.904)	.414 (2.859)	-.092 (2.838)		
R^2	.528	.487	.596	.589	.542	.599

NOTES:
Panel A: Correction of the observed supply L_i^* for net interstate migration; Panel B: Regional migration specification of the benefit from college education; Panel C: National migration specification of the benefit from college education.

[a]See page 83.

The dependent variable is ln L_i^*.

Standard errors in parentheses below coefficient estimates.

*, **, *** = statistical significance exceeding the .10, .05, and .01 levels, respectively, for a one-tailed test.

equation itself determines the strength of each when the other is accounted for. In effect this procedure permits the regression to determine the weights of each alternative specification in the explanation of the dependent variable.[1] The results of this test (Table 5, Panel C, column 2) show that BEN remains important while the effect of BENNAT drops nearly to zero. Therefore the best interpretation is that state labor markets for college educated labor are more applicable and a national labor market is less applicable for the prospective college student's determination of his economic benefit of a college education. The best estimate of the effect of this benefit on the supply of college educated labor is that reported under the state labor market hypothesis of Table 3.[2]

---

[1]Since the simple correlation between BEN and BENNAT is only .397, the problem of colinearity may not be serious.

[2]Another test of the applicability of a state or national labor market can be made by using BEN or BENNAT and the difference between the two in the supply equation, e.g.,

$$L_i^* = b_0 + b_1 \text{ BENNAT} + b_2 \text{ (BEN - BENNAT)} + \ldots \quad .$$

When this is done, the difference term is sizable and statistically significant when added to the equation containing BENNAT, but it is very small and not significantly different from zero when added to the equation containing BEN. Thus once the state BEN term is included, additional information yielded by the difference between the state and national benefits is not useful; but in the presence of the national benefit term, the additional information from the difference in the two benefit terms is important. This finding can be verified by rearranging the equation in this note above to $L_i^* = b_0 + (b_1+b_2)$ BENNAT + b_2 BEN + ... This is the equation estimated and reported in Table 5, Panel C, column 2. Thus the results of these two tests should be the same. And in fact the coefficient b_2 of the variable BEN-BENNAT was the same as the coefficient of BEN in Table 5, Panel C, column 2.

Age Group 25 or More Years

The supply model was estimated for the age group 25 or more years. Here the dependent variable is the change in the number of college educated white males from 1960 to 1970. This is the only difference in the supply equation for age group 25+ compared with age group 25-34. Results are reported in Tables 6 and 7. These tables correspond with Tables 3 and 5 for age group 25-34. The same alternative hypotheses about how prospective college students determine the expected benefit of a college education are used.

In all cases, the results are similar to those already discovered. The chief differences are that the coefficients of BEN, COST, and Y are slightly larger in magnitude for age group 25+. However, when the correction of the dependent variable for net interstate migration is made, these differences between the two age groups disappear, for all the benefit hypotheses. This similarity of results is not surprising. Recall that the change in the level of college educated men age 25+ from 1960 to 1970 is due mainly to entrants into this category. These entrants are men who acquired college education during the decade and who are 25-34 years old in 1970. This quantity--the level of college educated men age 25-34 in 1970 (the dependent variable in all the previous supply equations)--is just equal to the number of entrants from 1960 to 1970. This variable is not affected by the previous level of L_1^*. In other

TABLE 6. Estimated regression coefficients for the supply of college educated white males age 25 years or more, states of the U.S., 1970

Right-hand side variable	Benefit Hypothesis[a]	
	Current	Predicted
BEN	.344*** (.142)	.314*** (.124)
COST	-.880*** (.306)	-.887*** (.303)
HS	.402** (.186)	.450** (.189)
Y	.692* (.495)	.761* (.474)
LOAN	.141 (.127)	.116 (.122)
Q	-.270** (.136)	-.306** (.132)
constant	-1.632 (4.241)	-2.203 (4.145)
R^2	.496	.502

NOTES:
[a]See page 83.
The dependent variable is ln L_1.
Standard errors in parentheses below coefficient estimates.
*, **, *** = statistical significance exceeding the .10, .05, and .01 levels, respectively, for a one-tailed test.

TABLE 7. Estimated regression coefficients for the supply of college educated white males age 25 years or more, when there is geographic mobility, states of the U. S., 1970

Right-hand side variable (logs)	A Benefit Hypothesis[a]		B Regional Migration Benefit Hypothesis[a]	
	Current	Predicted	L_i, L_j Migrate	L_i Only Migrates
BEN	.278** (.137)	.188** (.124)	.357*** (.148)	.355*** (.146)
COST	-.576** (.296)	-.511** (.302)	-.878*** (.305)	-.874*** (.304)
HS	.445*** (.181)	.455*** (.189)	.390*** (.186)	.393** (.186)
Y	.288 (.479)	.456 (.472)	.671* (.500)	.720* (.488)
LOAN	.153 (.123)	.113 (.121)	.143 (.127)	.145 (.127)
Q	-.196* (.131)	-.231** (.132)	-.259** (.137)	-.267** (.136)
constant	-.639 (4.109)	-1.661 (4.127)	-1.588 (4.252)	-2.030 (4.179)
R^2	.361	.332	.496	.497

NOTES:

Panel A: Correction of the observed supply change ΔL_i for net interstate migration; Panel B: Regional migration specifications of the benefit from college education.

[a]See page 83.

The dependent variable is ln ΔL_i.

Standard errors in parentheses below coefficient estimates.

*, **, *** = statistical significance exceeding the .10, .05, and .01 levels, respectively, for a one-tailed test.

words, the dependent variable which is a level variable, L_i^*, is actually made up of a change over time and nothing else. And the rate of change dependent variable, ΔL_i, has the level variable L_i^* as its main component.

Summary

The main empirical result is that the economic benefits and costs of college education are important determinants of the supply of college educated white males. The investment theory of education is supported as an ex ante behavioral theory explaining why men go to college. An increase in the benefit of college education increases the number of college graduates. The elasticity of supply of college educated white males with respect to the benefit of college education is about .3. The implied supply elasticity with respect to the earnings of college educated workers is about 1.3. An increase in the cost of college education decreases the number of college graduates. The elasticity is about -.7.

Changes in the economic benefits and costs of college education have large effects on the market for college educated white males and on the higher education system. For example, if the earnings of college educated white males had been ten percent higher in 1960, they would have accounted for 23.2 percent of the labor force in 1970 instead of the actual 20.5 percent (age group 25-34). If the costs of going to college had been ten percent higher in

1960, there would have been a surplus of about 65 average size colleges in the decade of the 1960's or 32,000 unfilled places each year.

The human capital model suggests that college students use information on the current earnings of experienced workers to determine the benefit of college education. This result is supported by the empirical analysis. The hypothesis that prospective students predict the future earnings of college and high school educated workers does not add further explanation.

There is some probability that a college graduate will migrate out-of-state for employment. But apparently prospective college students do not use information on earnings in neighboring states to determine the benefit of college. In fact net interstate migration is not that large and thus has only small effects on the supply model. Because college educated workers are geographically mobile, there may be a national labor market and a single national earnings figure for them. But the evidence is that a national labor market is less applicable than state labor markets for the prospective college student's determination of the benefit of college.

The number of high school graduates eligible to go to college is not a constraint on the supply of college educated men. Less than one-sixth of additional high school graduates would go to college.

The ability to pay for college education is a determinant of the supply of college educated labor. Increases in family income result in increases in the number of college graduates. But the income elasticity of supply is inelastic, after the benefits and costs of college education have been taken into account. This suggests that the widespread belief that the demand for college education is income elastic is incorrect. Some of the effect of income on the stock of college graduates may reflect the purchase of education as a consumption good rather than the ability to pay for education as an investment good. The effect of government loans was quite small in 1960.

The non-market quality of education has a small but significant effect on the supply of college educated men. Rationing of places has little effect if any on the aggregate supply.

CHAPTER VI

ESTIMATION OF THE SUPPLY EQUATION: FEMALES

The supply model is applied to college educated white females. The hypothesis is that the investment theory of education will not provide a satisfactory explanation of the supply of college educated women. The investment return to college education is expected to be less important for women in the aggregate than men because some women spend many years of their lifecycle out of the labor force and in the household. For them, a household return rather than an economic market return is relevant.

The hypotheses are supported by the results. After taking female labor force experience into account, the market benefit of college education is perhaps one-fourth as important in determining the supply of young college educated white women as men, if indeed it has any effect at all. When a household return is added to the market return, a better explanation of the college-going behavior of women is obtained.

The Benefits and Costs of College Education

The parameters of the supply model were estimated for white women using equation (30). Data on the earnings of college and high school educated women were used to calculate the benefit and cost of college education for women. The number (share) of female high school graduates was used for the HS variable.[1] It was assumed that prospective female college students use information on current earnings of experienced workers to determine their benefit of college education (this gave the best results for males).[2]

The investment theory of education does not explain the college education decision of white females. The market benefit of a college education investment has only a small and imprecisely estimated effect on the supply of college educated white females. The coefficient of BEN is small (.056) and approximate (Table 8, column 1). (The 95 percent confidence interval around the coefficient of BEN does not overlap with the corresponding confidence interval for white males.) An anomaly is the positive COST coefficient (.110), although it is not statistically significant (its 95 percent confidence interval includes negative values down to -.170).

The effect of HS on L_i^* is stronger for women than

---

[1]Family income applies to both men and women students, so the Y variable is unchanged. Data on government loans is not available by sex, and the non-market quality of schooling is assumed to be the same for women as men.

[2]Migration hypotheses were not tested for females because they migrate much less than males. When they do it is often not a voluntary decision on their part which is responsive to female earnings differences, but rather it is their husband's decision.

for men. Similarly family income has a stronger and more precisely estimated effect on L_i^* for females than for males. This is consistent with a more critical ability to pay problem for women. It may also reflect a greater regard for the purchase of education as a consumption good rather than an investment good. The LOAN variable does not perform well, however.

Female Labor Force Experience

Many working women spend several years of their lifecycle out of the labor force (usually the child bearing years). The female benefit of college education should reflect these gaps in the earnings W_i and W_j of both college and high school educated workers (see equation [18], page 50). Since there is no data to permit this, a crude experience variable for women was constructed. It was used to correct BEN for female labor force experience. Since this correction is partially arbitrary, an experience variable was alternatively entered separately in the supply equation.

From the work of Mincer and Polachek (1973) the percent of years worked by college and high school educated white women in the U. S. can be learned. Since female labor force participation is heavily dependent on the presence or absence of children, state data on the number of childless college and high school educated women was used to obtain an index of female labor force experience for each state.[1]

[1]The calculation of BEN as $(W_i - W_j)$ * discount factor for men (see equation [10]) is modified to BEN = $(W_i \cdot EXP_i$

The result of taking variation in female labor force experience into account is to support the earlier conclusion that the investment theory of education does not apply with any force to white females. When the market benefit variable is corrected for the years of female work experience, the effect of BEN on L_i^* is increased from .056 to .073 (Table 8, column 2). Its estimated magnitude is about one-fourth the size of the corresponding coefficient for white males. However, it is not precisely estimated.[1] The coefficients of HS and Y remain larger than they were for white males. When the experience variable, EXP, is separately entered, it takes on the correct sign (Table 8, column 3). (The greater the number of childless college educated women relative to childless high school educated women, the greater the number of years worked by college educated women relative to high school educated women. Hence the true net return to college education is larger, given the annual

---

$- W_j * EXP_j) *$ discount factor, where EXP_i = index of labor force experience over the lifecycle of college educated working women ($EXP_i < 1$). EXP_i increases as the percent of childless college educated women increases. EXP_j refers to the experience of high school educated women. Since this correction of BEN is mathematically arbitrary, a new variable $EXP = EXP_i/EXP_j$ was calculated for each state and separately entered as a supply determinant.

[1]When the alternative log-linear functional form is specified, using NR alone instead of BEN and COST, the estimated coefficient of NR is .020. Although this is less than one-fifth the magnitude of the NR coefficient for white males, it was precisely estimated (standard error = .011). However, this functional form was earlier shown to be inferior to the log-linear form using BEN and COST separately (see p. 107).

TABLE 8. Estimated regression coefficients for the supply of college educated white females age 25-34, states of the U. S., 1970

Right-hand side variable (logs)	Treatment for Labor Force Experience		
	No Treatment	BEN Corrected	EXP Variable
BEN	.056 (.086)	.073 (.089)	.043 (.089)
COST	.110 (.156)	.080 (.164)	.079 (.165)
EXP			.065 (.101)
M	.638*** (.212)	.621*** (.213)	.533** (.269)
Y	.770** (.417)	.738** (.412)	.836** (.433)
LOAN	.056 (.099)	.056 (.099)	.036 (.105)
Q	-.061 (.125)	-.074 (.126)	-.092 (.135)
constant	-8.343** (3.674)	-7.820** (3.814)	-7.982** (3.746)
R^2	.496	.499	.502

NOTES:

The dependent variable is ln L_i^*.

The current earnings benefit hypothesis is used (see p. 83). See page 124 for an explanation of the treatments for labor force experience.

Standard errors in parentheses below coefficient estimates.

*, **, *** = statistical significance exceeding the .10, .05, and .01 levels, respectively, for a one-tailed test.

earnings difference between college and high school educated women.) No improvement in the performance of BEN or COST is obtained.

Household Returns

For women in general, the economic benefit of college education obtained through the labor market has very little effect on the supply of college educated women workers. Because some working women spend several years of their life out of the labor force, there may be a non-market household return which women get from a college education. Does a household return explain why women go to college?

One approach to this problem is to distinguish between observations on the expected strength of the market return vs. the household return motivation for investing in college education. The market return is assumed to be the relevant decision variable in states where it exceeds the household return, and conversely. The market return is judged to exceed the household return where there has been an average or greater increase in the labor force participation rate of young white females. The implicit assumption is that women will leave the household for the labor force when the return obtainable in the labor market rises above that obtainable at home. Econometrically, a dummy variable was added to the supply equation which permits the market benefit variable BEN to take on a higher coefficient when the market return is relevant and a lower coefficient when it is not. The result is that the effect of the market net return for women on the subsequent supply of women college graduates remains very small, even when it is presumably relevant and potentially operative. White women apparently do not take their market net return to college education seriously into account when making the college education decision. (Of course the use of labor force participation data to distinguish between states on the relevance of the market return is very simple and crude. Refinements could be attempted.)

The hypothesis that a household return explains the supply of female college graduates was tested directly.[1] The basic idea is that some women go to college for economic gain, but not from their own participation in the labor force. Rather, they go to college to increase their family income. One way they do this is by enlarging their marriage market, particularly to increase the chances of marrying a husband with high income and occupation prospects. Whether the female college graduate works every year or not, she will receive a benefit from being college educated if she marries a man whose income is higher than the man she would otherwise have married. Even if she does not marry a more highly educated man, she may be able via her own education

[1]The definition, measurement, and analysis of household returns is still very preliminary (see Michael 1973). In this study just one dimension of a household return is considered.

to increase her husband's income, given his education (Benham 1974). To test the former hypothesis, the supply equation for women was specified using the male market benefit in place of the female market benefit. The larger the market benefit to men, the larger the household return to women, and the larger the predicted stock of college educated women. Of course not all women choose to marry. For those who are single, their own female market return is relevant. The household return applies only to those women who marry. Therefore the household return (the male market benefit) is weighted by the proportion of married college educated women and the female market return is weighted by the proportion who are not married in each state. This gives a single variable for the benefit of college which reflects the household return and the female market return in their correct proportions.

An alternative specification of the household return was made using actual family income data. Ideally, one would use data on family income by education of the wife. This is not available so data on family income by occupation of head of family was used. The U. S. Bureau of the Census occupational category "professional, technical, and kindred workers" had a mean years of school completed for its members of 16.1 in 1960, and the two occupational categories, "clerical and kindred workers" and "sales workers" each had mean years of school completed for their members of 12.1. The difference between the earnings of the former and the latter occupational groups was used in the female household return term (family income). The assumption here is that high school educated women marry high school educated men, and that college educated women marry college educated men. Thus there are two equations to estimate the effect of a household return on the supply of college educated women. One uses the male market benefit (weighted with the female market benefit) to measure household returns (labeled BEN-MALE); the other uses a family income benefit defined by occupation of head of family (weighted with the female market benefit to measure household returns (labeled (BENFAM).

The result is that the male market benefit of college education (weighted with the female market benefit) has a significant positive effect (.231 in Table 9, column 1) on the supply of college educated females. In fact is is a stronger effect than that due to the female market benefit alone. This result is consistent with the hypothesis that some women (those who will be married) invest in a college education to get a household return, in particular, to increase the chances of marrying a higher income husband.[1] The alternative specification of this aspect of the household return, using family income defined by broad occupational categories, gives somewhat less convincing results.

---

[1]The male/female enrollment ratio was used as a variable in these equations, but its coefficient, although positive, was near zero and very imprecisely estimated. It was deleted in the estimation reported in Table 9.

TABLE 9. Estimated regression coefficients for the supply of college educated white females age 25-34 years, household return hypotheses, states of the U. S., 1970

Right-hand side variable (logs)	Household Return Hypothesis	
	Male Market Benefit	Family Income Benefit
BENMALE	.231** (.139)	
BENFAM		.147* (.097)
COST	-.079 (.197)	-.011 (.180)
HS	.747*** (.216)	.742*** (.218)
Y	.391 (.470)	.461 (.462)
LOAN	.099 (.100)	.081 (.099)
Q	-.048 (.121)	-.066 (.122)
constant	-5.781	-6.006
R^2	.524	.518

NOTES:

The dependent variable is ln L_i^*.

See page 127 for an explanation of the household return hypotheses.

Standard errors in parentheses below coefficient estimates.

*, **, *** = statistical significance exceeding the .10, .05, and .01 levels, respectively, for a one-tailed test.

Note that the effect of COST in either case is negative but quite small and not statistically significant.

In the household return equations, the single strongest influence on the supply of young white college educated women is the proportionate number of high school graudates. In the female market return equations, HS along with income (as an ability to pay and consumption demand indicator) has the largest effects. These results are consistent with the view that many women acquire a college education for reasons of a household return.

In sum, the investment theory of education holds only weakly, if at all, for prospective female college students. The effect of the net market return to a college education is about one-fourth as strong for females as it is for males, if it exists at all, even after the smaller amount of female labor force experience is taken into account. The use of a household return variable strengthens the view that the college education decision process is different for women than for men.[1]

---

[1]The supply equation for white females was also estimated for the age group 25 years or more.

The results were unacceptable since the coefficient of BEN was negative, the coefficient of COST was positive, the coefficient of HS was unreasonably large (>1.0), and no coefficients were statistically significant. When female labor force experience was taken into account, there was very little change in any of the coefficients. One explanation for these results for age group 25+ lies in the labor force participation behavior of females. Recall that a variable for the number of leavers from the college educated labor category from 1960 to 1970 was omitted from the empirical estimation of the equation above (for age group

25-34 no such variable is theoretically called for). For men the omission was not important, but for women it may be. The labor force participation rate for college educated women is not near 100 percent as it is for men; moreover, the in-and-out of the labor force behavior of women often depends not on economic reasons but rather on family and household reasons. Furthermore, the dependent variable is small; there is not much to explain. The data on ΔL_i shows that it averaged only 2.2 percentage points, from 7.6 percent in 1960 to 9.8 percent in 1970. On the other hand, ΔL_i for white males was 3.9 percentage points.

CHAPTER VII

ESTIMATION OF THE DEMAND EQUATIONS

Two variants of a demand equation for college educated labor are estimated. They differ according to the specification of the industry mix. First,

$$\ln L_i^* = b_0 + b_1 \ln W_i^* + b_2 \ln W_j^* + b_3 \ln R + \sum_{k=1}^{n} c_k \ln I_k + b_4 \ln Q + v \qquad (33)$$

where L_i^* = the share of white males age 25-34 with income who have i-16 or more years of school completed

W_i^*, W_j^* = indicators for rate of pay of white males with income age 25-34 years who have i=16+ and j=12 years of school completed, respectively: median annual income adjusted for unemployment and part-time working

R = an indicator for the price of physical capital: the gross rate of return to physical capital in the manufacturing sector, 1969-70 average, calculated as (value added--payroll)/book value of depreciable assets[1]

I_k = indicators for the industry mix in a state

---

[1]This indicator was used by Griliches (1969). If there is factor price equalization among industries within a state, the price of physical capital to the manufacturing industry should be the same as the price to other industries. Inter-industry heterogeneity of capital stock may be a problem, however.

Q = an indicator for the quality of educated labor factor L_i^*.

The variant of this demand equation attempts a better control for industry mix by using the indicator α_i/α_j as the industry mix variable, where α_i/α_j = the calculated ratio of the production coefficients of college and high school educated labor, respectively.

All wage variables are adjusted for interstate differences in the absolute price level, using the price level index previously described. Since the wage data from the Census is actually annual reported income, two adjustments were made to bring this data closer to the desired rate of pay indicator. The level of unemployment and the extent of part-time working in each state were taken into account. High unemployment and high part-time working would both contribute to low annual income. Since this will misrepresent rates of pay, their effects were taken out of the income data.

An indicator for the quality of workers in each state is added to the demand equation. Presumably the observed wage indicators W_i^* and W_j^* reflect differences in the quality of workers across states. But the observed quantity indicator L_i^* does not. High wages need not imply small quantity demanded if worker quality is high. A worker quality indicator (Q, from the supply model) is added as a demand curve shifter.

In the case of the structural demand equation it is clear that the wage variable is endogenous and the equation's parameters should be estimated in a simultaneous equations model. The order condition for the identification of the demand equation is fulfilled since the number of predetermined variables in the supply-demand model which are excluded from the demand relation is at least as great as the number of endogenous variables (two) in the demand equation. Two stage least squares estimation is used.

Findings for White Males

A problem in the specification of the demand equation is accounting for variation in the industrial composition of output across states. One approach is to use a sizable number of industry variables in the demand equation. The definition of industries by the U. S. Bureau of the Census has little regard for the skill or formal educational content of workers in industries. Therefore, many quite narrowly defined, specific, and hopefully homogenous industries were selected, hoping thereby that the skill content of each industry would be sufficiently uniform across states to permit it to serve as a demand curve shift variable. The selection criterion was the U. S. average educational attainment of workers in the industry. Both high-education and low-education detailed homogeneous industries were chosen in order to obtain broad coverage of a state's industrial composition. The size of these industries should affect the demand for college educated workers.[1] Following is a list of major industry groupings and the detailed industries used in this study (mostly SIC 3-digit). The symbols I_1, I_2, ..., I_{14} indicate the fourteen industry variables used in the demand equation.

Industry variables for the demand for college educated white males.

I_1:
- Agriculture, Forestry, and Fisheries
- Mining
  - Coal Mining
- Manufacturing
  - Durable Goods
  - Nondurable Goods
    - Textile mill products

Manufacturing
- Durable Goods
  - I_2:
    - Electrical machinery, equipment, and supplies
    - Professional and photographic equipment, and watches
- Nondurable Goods
  - I_3:
    - Chemical and allied products
    - Petroleum and coal products

Transportation, Communications, and Other Public Utilities
- I_4: Communications

Wholesale and Retail Trade
- Wholesale Trade
  - I_5: Drugs, chemicals, and allied products
  - I_5: Electrical goods
  - I_5: Hardware, plumbing, and heating supplies
- Retail Trade
  - I_5: Drug stores

[1]Altogether 33 detailed industries were selected, some from each of the major industry groupings. Then combinations of detailed industries with similar education levels within major industry groupings were made to reduce the number of industry variables to fourteen.

Finance, Insurance, and Real Estate

I_6 — Banking; Credit agencies; Securities, commodity brokers, investment companies

I_7 — Insurance; Real estate

Business and Repair Services

I_8 — Business services

Professional and Related Services

Health services

I_9 — offices of physicians; offices of dentists; offices of chiropracters; Legal services

Educational services

I_{10} — elementary and secondary schools

I_{11} — colleges and universities

I_{12} — Religious organizations; Welfare services; Engineering and architectural services; Accounting, auditing, and bookkeeping services

Public Administration

I_{13} — Postal service; Federal public administration

I_{14} — State public administration; Local public administration

Six of the industry variables had coefficients which were statistically significant in the first estimation. They were retained and the rest deleted.

The alternative specification of the industry mix uses the calculated ratio of the production coefficients, α_i/α_j.

The estimation of the demand equation indicates the demand for young college educated white males is wage elastic (Table 10). The coefficient of W_i^* is -1.513 when the α_i/α_j specification is used and about the same, -1.658, when the industry variables are used.[1] Both coefficients are precisely

[1]The coefficient of W_i^* when all fourteen industry variables were in the estimating equation was -1.478, which is only slightly different from its value after the non-significant industry variables were removed. Its standard error was higher, however.

estimated.[1]

Changes in the wages of high school educated labor have a large inverse effect on the quantity of college educated labor demanded. The cross-elasticity of demand for L_i^* with respect to W_j^* is positive and elastic. College and high school educated workers are apparently good substitutes in production.[2]

The price of physical capital, R, has only a small and imprecisely estimated effect on the demand for college educated labor. Two interpretations are possible. There may be a national market for physical capital (so its price is constant across states) or the indicator for R may be deficient. Note, however, that the positive sign of the

---

[1]Although the calculated industry mix variable, α_i/α_j, is theoretically desirable and empirically performs well, it is calculated as $(L_i^*/L_j^*)\cdot(W_i^*/W_j^*)$. The dependent variable L_i^* is one of four variables entering the calculation α_i/α_j. This means there may be a spurious component in the estimated coefficient of α_i/α_j. However, the coefficients of W_i^* and W_j^*, despite the calculation of α_i/α_j, are unbiased. Because their standard errors are low, multicollinearity between them and α_i/α_j is apparently not serious. Nevertheless, the ability of the alternate specification of the industry mix to yield essentially the same own-wage elasticity of demand is important evidence of the robustness of this coefficient.

[2]When the demand equation is estimated for age group 25-34, it may be that older college educated workers are substitutes as well as young high school educated workers. However, there is no empirical evidence on elasticities of substitution across age groups within educational categories to support this view. And U. S. time series estimates of the elasticity of substitution between college and high school educated workers age 25-34 by the author were not sensitive to the omission of older workers from the analysis. Since wages of college educated workers age 35-44 are highly colinear with wages for those age 25-34, estimation problems could be encountered.

TABLE 10. Estimated regression coefficients for the demand for college educated white males age 25-34, states of the U. S., 1970

Right-hand side variable (logs)	Industry Mix Specification	
	Ratio of Production Coefficients	Industry Variables
W_i^*	-1.513*** (.270)	-1.658*** (.473)
W_j^*	1.417*** (.238)	1.408*** (.360)
R	.017 (.040)	.092 (.071)
Q	-.078* (.054)	-.177* (.084)
α_i/α_j	.666*** (.051)	
I_1		-.140*** (.033)
I_2		-.085*** (.025)
I_6		.267** (.115)
I_7		.327** (.140)
I_{13}		.094** (.045)
I_{14}		-.435*** (.120)
constant	4.720** (1.940)	6.266*

NOTES:
Two stage least squares estimation.
The dependent variable is ln L_i^*.
Standard errors in parentheses below coefficient estimates.
*, **, *** = statistical significance exceeding the .10, .05, and .01 levels, respectively, for a one-tailed test.

physical capital coefficient suggests that physical capital and college educated labor may not be complementary in production, as tentatively advanced by Griliches (1967), using the same indicator for the price of physical capital, and by Berndt and Christensen (1974).

Among the industry variables (column 2) there are sizable positive demand curve shift effects due to I_6 and I_7, which are the two detailed industry combinations in the major industry group of finance, insurance, and real estate. There is a sizable negative effect due to I_{14}, which is state and local public administration. Changes in the size of the state and local government bureaucracy are inversely related to changes in the demand for college educated labor, whereas changes in the size of the federal bureaucracy in a state is positively related to changes in their demand, when other demand determinants are held constant.[1]

A demand equation was also estimated for college educated white males age 25+, using the six industry variables:

---

[1]In Chapter IV the question of the exogeneity of the industry mix in the factor demand equation was raised. The conclusion was that on theoretical grounds it was exogenous. A rough empirical test was also made by assuming that, on the contrary, industry mix is endogenous, and deleting it as an instrumental variable in the two stage least squares estimation of the factor demand equation. When this was done for the age group 25-34 using α_i/α_j as the industry variable, there was no change in the coefficients of W_i^* or W_j^*, and only a very slight increase in the coefficient of α_i/α_j. This provides further evidence for believing that the industry mix is an exogenous variable in the demand equation for college educated labor.

$$\ln L_i = \underset{(3.571)}{.976} - \underset{(.618)}{.610} \ln W_i + \underset{(.468)}{.920} \ln W_j + \underset{(.073)}{.013} \ln R$$

$$- \underset{(.093)}{.206} \ln Q - \underset{(.032)}{.185} \ln I_1 - \underset{(.025)}{.093} \ln I_2 + \underset{(.117)}{.053} \ln I_6$$

$$+ \underset{(.142)}{.420} \ln I_7 + \underset{(.044)}{.176} \ln I_{13} - \underset{(.136)}{.358} \ln I_{14} \qquad (34)$$

In this case the own-wage coefficient is inelastic and not precisely measured, and the cross elasticity of demand is much smaller (but it still indicates a relationship between L_i and L_j of substitution in production).

The wage elasticity of demand for older workers would expected to be smaller than for younger workers due , reasons of specific vs. general human capital, as Becker has defined them (Becker 1962). Older workers, with longer job tenure, are likely to have more specific human capital than younger workers. Firms will be less likely to release employees with specific training than employees without it when market wage rates increase. If it does, the firm will lose the chance to recover its investment in the employee, if the firm paid for the training, or the firm will be unable to find an equally profitable new employee, if the old employee paid for the training. Thus the quantity demanded of college educated workers who have specific on-the-job training will be less responsive to wage changes than the quantity demanded of college educated workers without specific training. In addition states may differ in the age distribution of college educated workers, so that the estimation of the demand equation for a more homogeneous age group should give better results, as in fact it did.

Findings for White Females

Factor demand equations were also estimated for college educated white females. A somewhat different list of industries is used, based on the same selection criterion used for males.

Industry variables for the demand of college educated white females.

I_1 — Agriculture, Forestry and Fisheries

Manufacturing
- Nondurable Goods
  - I_2 — Tobacco manufacturers
  - I_2 — Textile mill products
  - I_2 — Apparel and other fabricated textile products
  - I_2 — Leather and leather products

Transportation, Communication, and other Public Utilities
- Transportation
  - I_3 — Air transportation
  - I_3 — Petroleum and natural gas pipelines
  - I_3 — Services incidental to transportation
- Communications
  - I_3 — Radio broadcasting and television
- Utilities and Sanitary Services
  - I_3 — Electric light and power
  - I_3 — Electric-gas utilities
  - I_3 — Gas and steam supply systems
  - I_3 — Water supply

I_4 — Finance, Insurance and Real Estate

Business and Repair Services
- I_5 — Business services

Professional and Related Services
Educational services
I_6 ———— elementary and secondary schools
I_7 ———— college and universities
I_8 ———— (all other professional services)

Public Administration
I_9 ———— Federal public administration
I_{10} ———— State and public administration
———— Local public administration

The results of the estimation of the demand equations for young white college educated females are that the effects of wage changes on quantity demanded are smaller in magnitude than for white males. The wage elasticity of demand for college educated white women is inelastic (-.587 in Table 11, column 1). So also is the cross-elasticity of demand with respect to high school educated women. The smaller substitutability between college and high school educated females compared to males is expected. Many females are in occupations such as elementary and secondary teaching (the educational services industry accounts for 13.5 percent of all female employment) where a college degree is mandatory and there is no substitution possibility. This would also tend to make the own-wage elasticity lower.

The specification of the demand equation using industry variables (column 2) gives coefficient estimates similar to the specification using α_i/α_j. However, statistical significance is low.[1]

[1]The original ten industry variables were reduced to six in the first estimation of this demand equation.

TABLE 11. Estimated regression coefficients for the demand for college educated white females age 25-34, states of the U. S., 1970

Right-hand side variable (logs)	Industry Mix Specification	
	Ratio of Production Coefficients	Industry Variables
W_i^*	-.587** (.304)	-.683 (1.180)
W_j^*	.624*** (.166)	.800 (1.196)
R	-.019 (.030)	-.020 (.100)
Q	-.031 (.038)	-.280 (.100)
α_i/α_j	.850*** (.048)	
I_2		-.024 (.033)
I_3		.753 (.703)
I_4		.392* (.266)
I_6		.106 (.241)
I_7		.041 (.188)
I_9		.021 (.054)
constant	3.129** (1.706)	2.786* (1.711)

NOTES:
Two stage least squares estimation.
The dependent variable is ln L_i^*.
Standard errors in parentheses below coefficient estimates.
*, **, *** = statistical significance exceeding the .10, .05, and .01 levels, respectively, for a one-tailed test.

Summary

The evidence from the estimation of the demand equations suggests that the wage elasticity of demand for young college educated white men is elastic, about -1.5. For older white men, the demand elasticity is inelastic, about -.6 (perhaps due to more firm-specific training in older workers). College and high school educated workers are substitutes in production. Young college and high school educated men are better substitutes than their older counterparts. The industrial composition of output is an important factor demand curve shifter, whether measured by a calculated ratio of production coefficients or a series of industry variables.

The wage elasticity of demand for young college educated white women is inelastic, about -.6. Substitutability between college and high school educated women is smaller than for men. This may reflect the predominance of women in occupations such as teaching and nursing, where a college degree is usually mandatory.

CHAPTER VIII

PROJECTIONS OF THE SUPPLY OF COLLEGE EDUCATED LABOR: A POLICY APPLICATION

The results from the supply model suggest that the investment theory of education is viable as an *ex ante* explanation of the college-going behavior of white males; that the benefits and costs of a college education are important in determining the future stock of college educated men supplied to the labor force. The analysis also suggests that the labor market for college educated white males works; that the wage elasticities and demand shift parameters are consistent with observed events in this market and with conventional economic theory. These successful research outcomes suggest a specific policy use to which the supply model in this paper may be put. That policy application is the projection of educational attainment in the future.

The future number of college educated people has been a matter of public concern and private concern as well. However, only limited projection efforts have been made. The first published projections of educational attainment of any kind by a government source is a very brief and modest 1947 U. S. Office of Education effort.[1] The Bureau of the Census first did such projections in 1959.[2] A private effort, by the Metropolitan Life Insurance Company, was done in 1958.[3] Subsequently, the Bureau of the Census has made additional projections for the population, and more recently the Bureau of Labor Statistics has done so for the labor force.[4]

The basic technique used by the projections is the extrapolation of time trends. No economic, sociological, or political inputs are used. In fact the assumption of ". . . no unusual political or economic conditions . . ." is explicitly made. And there is a disclaimer that ". . . these projections should not be regarded as predictions, but rather as patterns of educational attainment resulting from specified assumptions about . . . future proportions (of the population) attending school at each age."[5] But of course it is precisely the existence of political and economic change which makes forecasting necessary and which

---

[1]Eldridge, Hope Tisdale and Joel Williams, "School Population of the Future," School Life 30 (November 1947).

[2]U.S. Bureau of the Census, Current Population Reports, Series P20, Population Characteristics, " Projections of Educational Attainment in the U. S.: 1960 to 1980," no. 91, January 1959.

[3]Metropolitan Life Insurance Company, Statistical Bulletin, no. 39, August 1958.

[4]See the Special Labor Force Report series of the U. S. Bureau of Labor Statistics, no. 95.

[5]U.S. Bureau of the Census, "Projections," p. 2.

makes extrapolative projections inadequate. But now quantitative information from the supply model in this study on college education decision variables--what they are and how large their effects are--leads to a hope that previous demographic projections can be improved. In particular, can current changes in earnings, costs of college, family income, and other supply determinants in a human capital model be used to increase the accuracy of 10 year projections of college educated men?

U. S. Bureau of the Census Projections

A publication of the U. S. Bureau of the Census (cited above) made projections in 1959 of the share of college educated males and females in the population by age group for 1970. The latest data used for these projections was 1957 data. The supply analysis in Chapter V of this study used 1959 and 1960 data to explain the 1970 college educated labor stock by age group. Thus not only can the accuracy of the Census projection be checked (since 1970 is past), but also the time points and time span of the Census work and the research in this study correspond. This means that the two approaches, extrapolation and human capital, can be directly compared.

The Census projections are for the entire adult population (rather than the labor force), and for age groups 25-29, 30-34, ..., as well as 25+. The projection for age group 25+ is largely a mechanical matter, since the number of college educated people who will be age 35+ in 1970 is approximately known from actual data on the number of such people age 25+ in 1960 (this is close to the 1957 data point which the Census used). It is approximate rather than exact only if mortality rates differ by educational level or change in ten years, or if there are changes in educational attainment after age 25 (e.g., from 1-3 years of college to 4 or more years of college). Only the projection of educational attainment for age group 25-34 in 1970 requires a trend extrapolation. Therefore this age group is chosen for comparison with the human capital results above. (Also, almost all males age 25-34 are in the labor force, so population and labor force data are nearly interchangeable.) Two alternative extrapolations for age group 25-34 were made in the Census projections. The schematic below illustrates the technique (Figure 4).

The 'B' projection was obtained by extrapolating the trend of all eight five-year age groups, while the 'A' projection used only the trend of the youngest three age groups, which showed a slight upturn. These extrapolations then apply to age group 25-34 in 1970.

Table 12 shows the 1959 Census projections for 1970 for three educational levels compared to actual 1970 levels.

These results show that for college educated males age 25-34 the 'A' projection was low by 1.8 percentage points or 10.5 percent and the 'B' projection was low by 3

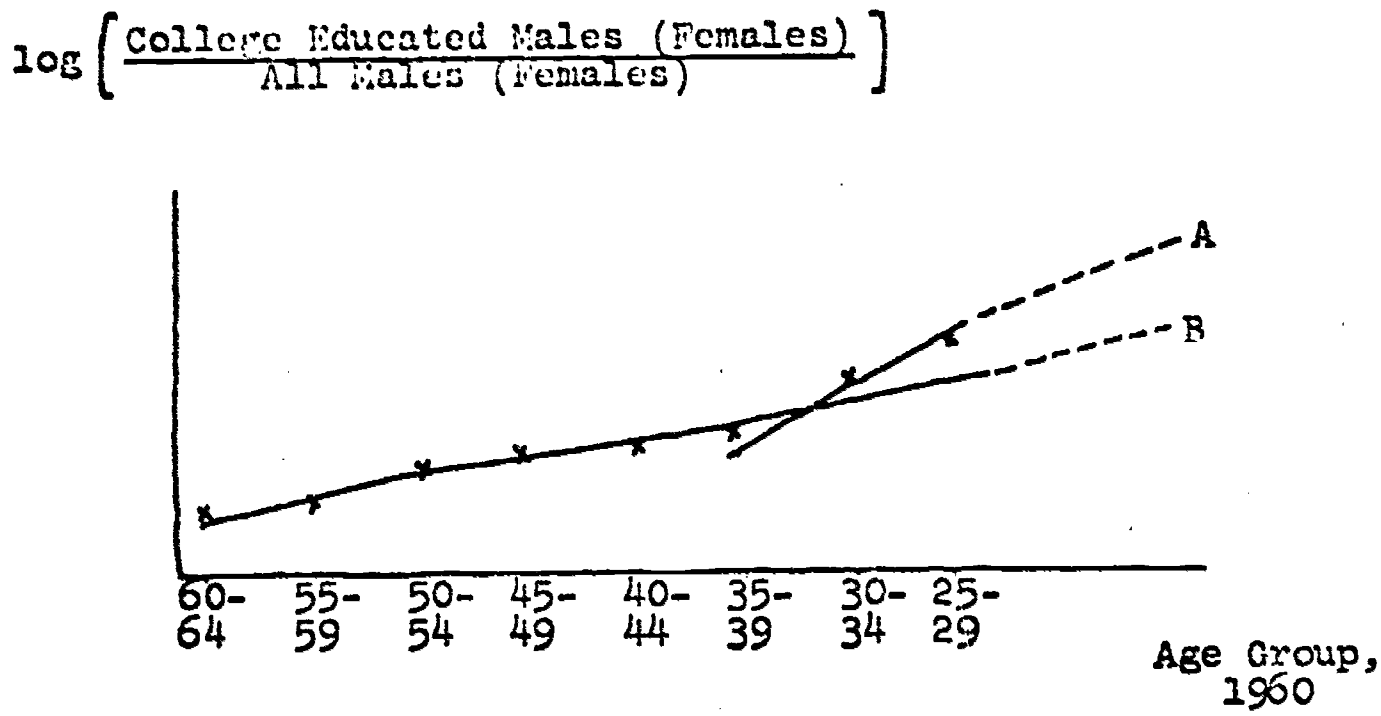

Figure 4. U. S. Bureau of the Census projection technique for college educated persons

TABLE 12. 1959 U. S. Bureau of the Census projections of educational attainment for males age 25-34 for 1970 and actual 1970 levels (percent of population)

Years of School Completed	Projections		Actual 1970	Percentage Error	
	A	B		A	B
12	37.6	35.0	37.6	0	- 7.4
13-15	13.1	12.3	15.4	-17.6	-25.3
16 or more	17.2	16.0	19.0	-10.5	-18.8

NOTES:
See above for description of 'A' and 'B' projections.

SOURCES: See footnote 2, p. 148, and U.S. Bureau of the Census, Census of Population, 1970 1, U. S. Summary, Ch. D (Detailed Characteristics).

full percentage points or 18.8 percent. Thus there is room for improvement.

Human Capital Model Predictions

The results of the supply model (Chapter V) can be used to predict the future U. S. stock of college educated males since it quantifies the effect of supply determinants on the subsequent stock of college educated men. The supply model is cross-sectional, using state data on supply determinants in 1960 and state data on the stock of college educated males in 1970. To make the prediction desired, aggregate U. S. data on each of the supply determinants is required. Then the estimated regression coefficients from the supply equation are applied to average U. S. values of the supply equation variables in 1960 to obtain the predicted 1970 supply of college educated males in the U. S.[1] This prediction application of the supply model is a test of its usefulness as an aid to policy formulation. It is a stringent test because it uses cross-sectionally estimated relationships between explanatory and dependent variables to predict a time-series change in the dependent variable.

The result of using the supply model to predict the future stock of college educated males is that a considerable improvement is made over the extrapolative projections

[1]Since the Bureau of the Census projections are for total males (not just white males), the supply equation in this study was reestimated using data for total males.

of the Bureau of the Census. The human capital supply model predicted in 1960 that college educated males age 25-34 would account for 19.7 percent of all males in that age group in the U. S. in 1970 (Table 13). The actual figure

TABLE 13. Predictions of the human capital model, projections of the U. S. Bureau of the Census, and actual stock of college educated males age 25-34 in 1970, U. S. (percent of population)

Item	College Educated Males Age 25-34 (percent of population)	Percent Error
Actual 1970	19.0	
Predicted 1970		
Human Capital Supply Model	19.7	+ 3.7
Census 'A'	17.2	-10.5
Census 'B'	16.0	-18.8
Combined	18.7	- 1.6

was 19.0 percent. The prediction error was +3.7 percent. The best Census projection, based on recent trends, was 17.2 percent, an error of -10.5 percent, while the other Census projection, based on a longer history, was 16.0 percent, an error of -18.8 percent. Thus not even the best ten year projection, which was sensitive only to recent trends, was high enough. The use of economic information in the human capital prediction was better able to account for changing trends. But this is just the point: the human capital based economic prediction is intended to use the information

which is fundamentally responsible for changing trends, and should therefore provide a better prediction than a trend extrapolation. Indeed the Census projection work acknowledges this.

Nevertheless, there was error in the human capital model prediction as well, which may be due to data deficiencies or to model deficiencies. The maximum degree of explanatory power achieved by the supply equations of this model was $R^2 = .60$. This may be due to the influence of non-economic variables which are not in the human capital model. Therefore it would seem advisable to use both the economic model prediction and the time trend extrapolation together (since the latter may reflect non-economic influences) to improve the accuracy of the prediction. When this is done, the combined prediction figure is 18.7 percent. This is an error of only -1.6 percent.[1]

One further prediction exercise can be done using the human capital supply model. The 1970 share of white college educated males can be predicted, using the coefficients in Table 3. Although there is no comparable Census projection, the prediction can be judged against the actual outcome. The economic prediction for white males may be

[1]The prediction of the supply model was weighted by .60 and the extrapolative projection was weighted by .40 to obtain the combined prediction. This weighting scheme was chosen because the supply equation explains 60 percent of the variation in the stock of college educated men, leaving 40 percent to be explained in other ways.

slightly superior to that for total males since the supply equation for white males was estimated with slightly more precision than was the supply equation for total males. The result is that the supply equation predicted that white college educated males age 25-34 would account for 20.3 percent of all white males in the U. S. in 1970. The actual figure was also exactly 20.3 percent. These results further confirm the validity of the human capital based supply equation for college educated labor, not only for purposes of explanation but also for purposes of prediction.[1] Table 13 summarizes the predictions.

The promise shown by this human capital model in predicting the future stock of college educated males is especially important now, since there may be a reversal in the last decade's uptrend in college enrollment. When turning points in trend lines are reached, trend extrapolation is particularly error-prone, and more sophisticated models become necessary. Economic information can profitably be added to demographic information to improve the accuracy of predictions of the future supply of college educated men.

If a human capital investment theory of education approach proves to be successful in prediction, a new and

---

[1]The supply equation containing the net return variable was used for these predictions as well as the ones above for all males. The supply equation containing separate benefit and cost terms gave slightly less accurate predictions. They were still better than the time trend extrapolations, however.

powerful tool is suggested to educational planners as well as to manpower policy makers. If current information on earnings, college costs, family income, and government loans can be used to improve the existing simplistic projections of the future numbers of college educated workers, then changes in the demands to be made upon the higher education system can be more accurately forecast.

CHAPTER IX

SUMMARY

Theory

The chief objective of the study is to explain the supply of college educated labor using human capital theory. The investment theory of education is tested as an *ex ante* behavioral hypothesis. Do the private market benefits and costs of a college education determine the subsequent stock of college educated labor? The demand for college educated labor is also studied to identify the important determinants of the demand for college educated workers.

The supply of college educated labor is made a function of the private market benefits and costs of investing in a college education, and of exogenous determinants. The market benefit of a college education is the discounted difference in the earnings stream of college vs. high school educated workers over the life cycle. The costs of college are the direct costs, such as tuition, and the foregone earnings given up while a student. Different hypotheses are developed and tested on whether prospective college students use current or predicted future earnings to determine their anticipated benefits from college.

The benefits from a college education are affected by geographic mobility of workers. The effect of net interstate migration on the benefit from college is accounted for in two alternative ways: By incorporating observed regional migration into the model, and by assuming complete national migration and a national labor market.

Exogenous determinants of the supply curve are (1) the stock of high school graduates eligible to go to college, (2) family income and government loans, and (3) the quality of schools. Because there are imperfect capital markets for the personal finance of college education, the ability to pay for the investment should affect the stock of college educated workers. Family income and government loans are indicators of the ability to pay. The amenities which schools provide may affect the college education decision, and so indicators for the non-market quality of schooling were used. The possibility of rationing of places is also considered.

The investment theory of education appears to be less applicable to females in the aggregate than to males. In part, this is due to the fewer years spent in the labor force by females than males. Some females may therefore go to college to get a household return rather than a market return. The household return hypothesis suggests that some females may go to college to increase their future family income by increasing their chances of marrying a husband with high income and professional occupation prospects. (The hypothesis is not that some females go to college to find a husband, but rather that they increase their range of marriage opportunities.) Or women who marry may help increase their husband's income (given husband's education) by increasing their own skills.

A model for the demand for college educated labor is based on the neoclassical tradition of deriving the demand for a factor from a (Cobb-Douglas) production function. The demand equation for college educated labor was specified using the wage rate of college educated workers, the prices of related factors of production (high school educated labor and physical capital), the industrial composition of output (as an output demand curve shift variable), and the quality of workers. Two methods were used to measure industrial composition of output: the calculated ratio of the coefficients of the production function, and a series of indicators for the size of different industries.

The supply model was used to predict the 1970 stock of college educated males in the U. S. from 1960 data on supply determinants. These predictions were compared to U. S. Bureau of the Census projections and actual 1970 outcomes.

Evidence

The empirical analysis is cross-sectional, using states of the U. S. as units of analysis.

The evidence suggests that prospective white male college students respond to changes in the economic benefits and costs of a college education. An increase in the benefits increases and an increase in the costs decreases the subsequent stock of college educated male workers. The success of this simple investment model of education suggests that human capital theory is useful in the ex ante behavioral explanation of the supply of college educated men as well as in the ex post assessments of its rate of return.

The quantity response of the stock of young college educated white males with respect to changes in the economic benefit of college is positive but inelastic, about .3 (see Table 14). But the implied earnings elasticity is greater than unity, about 1.3. The effect of changes in the costs of college is negative and also inelastic, at -.7. Costs are estimated to have a larger effect than benefits on the subsequent supply of college educated men. This may be because the costs are immediate and well-known while the benefits are distant and uncertain (or the coefficient of the benefit variable may be biased downward due to measurement errors).

The results indicate that if the earnings of college educated white males with income had been 10 percent higher in 1960, they would have accounted for 23.2 percent of the male labor force in 1970 instead of the actual 20.5 percent (age group 25-34). The earnings of high school educated men have as large an effect as the earnings of college educated men on the supply of college educated men. This is because the earnings of high school educated workers affect both the benefits and the foregong earnings costs of a college education.

The effect of the costs of college can be illustrated in terms of its impact on the higher education system. If the total costs of college had been 10 percent lower in 1960 than they actually were, there would have been a need for an additional 32,000 places in colleges each year, which amounts to about 65 additional average size colleges.

College students appear to use information on current earnings of experienced workers to estimate the benefits of college rather than predict earnings of workers in the future.

There is some probability that workers will migrate to other states for employment after college. Hypotheses which assumed that prospective college students use information on earnings differences in other states to determine their benefit from college did not give materially different results from those above. This may be due to the fact that net interstate migration in a single year is quite small, or because migration probabilities do not figure in the prospective student's determination of his benefit from college. The hypothesis that there is a national labor market for college educated workers does not succeed in explaining the supply of college educated men. Although there may be a national labor market, it is apparently not applicable to the prospective college student's determination of his benefit from college. Most importantly, the existence of geographic mobility of workers, whatever its scope, does not alter the conclusion that the investment theory of education is valid in ex ante decisions.

The number (share) of high school graduates eligible to go to college does not have a large effect on the subsequent stock of male college educated labor. Very few of the marginal high school graduates, less than one-sixth, would go on to complete college.

The ability to pay for a college education is a significant determinant of the stock of college educated labor. Increases in family income are associated with subsequent increases in the number of college educated workers. However, the elasticity is less than one, suggesting that the widespread belief that the demand for education is income elastic may not be correct. Some of the effect of income may reflect the purchase of education as a consumption good rather than the ability to pay for education as an investment good. The effect of government loans, while also positive, was quite small and less than the effect of family income. This may be due to the newness and small size of government loans in 1960. The effect of government loans was smaller than the effect of costs; reducing the costs of college attendance would be expected to have a larger effect on college-going than simply increasing the ability of a student to defer the payment of the costs.

The experiments with alternative indicators for the non-market quality of colleges suggest that prospective students do consider this dimension, but the effects in the aggregate are small. A larger stock of college educated labor is associated with a smaller acceptance rate of applications for admission, or a larger share of private vs. public enrollment, or a higher Gossman "attractive" index, with all other supply determinants constant. The possibility of rationing of places as a constraint on college attendance was considered. The empirical evidence suggested that rationing existed in insignificant amounts.

The investment theory of education is not a satisfactory model for the explanation of the supply of college educated white females. In aggregate, white females respond very little to changes in their market net return from a college education. After taking into account the fact that working women have less labor force experience than men, the effect of their market benefit from a college education is about one-fourth that of white males, if indeed there is any effect at all. On the other hand, family income and the number of high school graduates were more important for women than men.

Because many women spend some years out of the labor force and in the household, a household return may motivate their college attendance. One household returns hypothesis is that some women go to college to increase their chances of getting a higher future family income either by increasing their range of marriage opportunities--particularly the chances of marrying a husband with prospects for high income and a professional occupation--or by being able to increase their husband's income given his education. This reason might apply to some women who marry, but not to those who do not marry. Empirically the male market benefit from college (weighted with the female market benefit according to proportionate numbers married) was a significant determinant of the subsequent supply of female college educated labor, even though the female market benefit alone was not. Although this treatment of the female college decision is preliminary and incomplete, it is at least clear that the supply of college educated females cannot be explained in the same way as for males.

The demand equation for college educated workers was estimated in a simultaneous equations supply-demand model by two stage least squares. The demand for young college educated white males in 1970 was wage elastic, about -1.5. The wages of high school educated male workers had a strong positive effect on the demand for college educated male workers, suggesting that college and high school educated men are indeed substitutes in production.

The industrial composition of output was an important determinant of the demand for college educated labor. But the industry mix effects were smaller than the wage effects. Among those industries which were included, the strongest positive effects on the demand for college educated white males were shown by two finance, insurance and real estate industries, and the largest negative effect was shown by the state and local public administration industry. The alternative specification of the industry mix as the ratio of the production coefficients, α_i/α_j, did not affect the size of the estimated wage elasticities.

The own-wage elasticity of demand for young college educated white females was inelastic, about -.6. The cross-elasticity of demand between high school and college educated white females was also smaller than for white males, indicating fewer substitution possibilities. This is consistent with the observed occupational distribution of females. There is a concentration of college educated females in the education services industry where there is little substitution possibility with high school educated females.

The human capital model proved to be an accurate predictor of the 1970 supply of young college educated males in the U. S., using 1960 data on supply determinants. The model predicted that college educated males age 25-34 would account for 19.7 percent of all males of that age in 1970, while the actual figure was 19.0. The best U. S. Bureau of the Census projection was 17.2 percent. Thus the supply model made an error of 3.7 percent while the Census error was 10.5 percent. When the supply of young white college educated males in the population was predicted, the human capital model made no error, giving a figure of 20.3 percent, which was the actual figure realized.

Policy Implications

By combining the estimated supply equation and demand equation parameters for college educated labor, the operation of the labor market for college educated workers can be understood. This supply-demand model documents for the first time the reasons for the large increase in the number of college educated males over time, and the reasons why their relative earnings level had not, until 1970, fallen.

First, the stock of college educated white males supplied to the labor force is in fact responsive to changes in the earnings of college educated workers as they are expressed in changes in the market benefits of investing in college education. Real increases in the difference between the earnings of college and high school educated workers over time have provided an economic incentive for the expansion of the supply of college educated workers. And prospective male college students have in fact behaved as if the investment return to a college education were an important education decision variable. The absolute dollar value of the net return to a college education has increased over time. This, fundamentally, is why there has been an increasing supply of college educated white males.

Other variables which have effects on the future supply of college educated males are the number of eligible high school graduates, family income, and government loan funds. All these variables have positive effects, and all have increased over time. However, increases in family income will not, according to this analysis, have a dominant impact, contrary to popular belief.

The findings of this study document the reasons why the real wages of college educated white males have failed to decline absolutely and relati to the wages of high school educated workers. First, the demand for these college educated workers is wage elastic, so that there are no large decreases in their wages, moving along the demand curve, as the supply increases. Second, the demand curve readily shifts out if the wages of high school workers rise, and if the aggregate industrial composition of output becomes more intensive in the use of college educated workers. Both these events have been occurring. (Of course, explanations of time series events from cross-sectional analysis must be guarded. But roughly the same observed relationships between quantities and wages hold across states as well as over time. And the time-series analysis of Freeman [1971] contains conclusions consistent with those above.)

This knowledge of some basic parameters of the labor market for college educated white males is important for manpower policy. A fundamental conclusion of this study is that this labor market does in fact behave in accordance with conventional economic relationships. When coupled with Freeman's findings on the disequilibrium adjustment pattern of certain high-education occupations, the findings of this study suggest that the stock supplied and the quantity demanded of college educated men respond to changes in their wages. These findings indicate, e.g., that policies of improving information flows are likely to bring results, and that on the other hand, policies of direct intervention are likely not necessary. The nature of manpower policy here should be one of facilitating market adjustments, and the scope of manpower policy need not be extensive.

Quite different implications apply to white females. The labor market for white female college educated labor can not be counted on to produce the expected economic results. The supply is not responsive to changes in market earnings or the market benefits or costs of a college education. Non-market variables appear to be more important. The quantity demanded is not nearly so responsive to changes in wages as was true for males. Research on the forces influencing the college education and employment decisions of white females is needed; at least it is apparent that there is room for public policy here, although what that policy should be is not known.

TABLE 14. Summary of estimated regression coefficients (elasticities) for the supply and demand for college educated labor age 25-34, states of the U. S., 1970

Right-hand side variable (logs)	White Males	White Females
A. Supply		
BEN	.297	n.s.
COST	-.727	n.s.
HS	.466	.621
Y	.476	.738
LOAN	.180	n.s.
Q	-.223	n.s.
R^2	.597	.499
B. Demand		
W_i^*	-1.513	-.587
W_j^*	1.417	.624
R	.017	-.019
Q	-.078	-.031
1/ j	.666	.850

NOTES:

The dependent variable, L_i^*, is the natural logarithm of the share of college educated workers in the labor force. Right=hand side variables, in natural logarithms, are: BEN, COST = benefit and cost of college education in dollars (BEN for females corrected for labor force experience); HS = high school graduates as a share of the population age 17; Y = family income of families with children age 18 or less; LOAN = government loans per enrolled student; Q = non-market college quality indicated by the acceptance rate; W_i^*, W_j^* = rate of pay of college and high school educated workers;

R = price of physical capital indicated by the gross rate of return to depreciable assets in manufacturing; α_i/α_j = industry mix indicated by the ratio of production coefficients α_i, α_j.

All coefficients in the supply and demand equations for white males are statistically significant exceeding the .05 level except Y and Q in the supply equation, which are significant at the .10 level, and R in the demand equation. For white females, BEN, COST, and LOAN in the supply equation and R and Q in the demand equation are not statistically significant (indicated by "n.s.").

Demand equation estimated by two stage least squares.

Supply equation right-hand side variables measured in 1960.

LIST OF REFERENCES

Astin, Alexander W. Who Goes Where to College? Chicago: Science Research Associates, 1965.

Becker, Gary S. Human Capital. Princeton: Princeton University Press, 1964.

________. "Underinvestment in College Education." American Economic Review 50 (May 1960): 346-52.

Benham, Lee. "Benefits of Women's Education within Marriage." Journal of Political Economy 82, Part II (March/April 1974): 557-71.

Berndt, Ernst R., and Christensen, Laurits R. "Testing for the Existence of a Consistent Aggregate Index of Labor Inputs." American Economic Review 64 (June 1974): 391-404.

Blaug, Mark. An Introduction to the Economics of Education. London: Allen Lane, 1970.

Bowman, Mary Jean. "The 'Fit' Between Education and Work." In Super, Donald E., ed. Toward a Cross-National Model of Educational Achievement in a National Economy.

Campbell, Robert, and Siegel, Barry N. "Demand for Higher Education in the U. S., 1917-1964." American Economic Review 57 (June 1967): 482-94.

Carney, Martin, and Marenbach, Dieter. "The Return to Schooling in the U. S., 1939-69." Unpublished paper, 1974.

Denison, Edward F. The Sources of Economic Growth in the U. S. and the Alternatives Before Us. Supplemental Paper No. 13. New York: Committee for Economic Development, 1962.

Freeman, Richard B. The Market for College Trained Manpower. Cambridge: Harvard University Press, 1971.

Gossman, Charles S., et al. Migration of College and University Students in the United States. Seattle: University of Washington Press, 1968.

Gould, John P., and Waud, Roger N. "The Neoclassical Model of Investment Behavior: Another View." International Economic Review 14 (February 1973): 33-48.

Gourman, Jack B. The Gourman Report: Ratings of American Colleges. 1967-68 ed. Phoenix: Continuing Education Institute, 1967.

Griliches, Zvi. "Capital-Skill Complementarity." Review of Economics and Statistics 51 (November 1969): 465-68.

________. "Production Functions in Manufacturing: Some Preliminary Results." In Murray Brown, ed. The Theory and Empirical Analysis of Production. National Bureau of Economic Research, Studies in Income and Wealth 31. New York: Columbia University Press, 1967.

________. "Research Expenditures, Education, and the Aggregate Agricultural Production Function." American Economic Review 54 (December 1964): 961-74.

Hanoch, Giora. "An Economic Analysis of Earnings and Schooling." Journal of Human Resources 2 (Summer 1967): 310-29.

Hansen, W. Lee. "Total and Private Rates of Return to Investment in Schooling." Journal of Political Economy 81 (April 1963): 128-40.

Henderson, James M., and Quandt, Richard E. Microeconomics: A Mathematical Approach. 2d ed. New York: McGraw-Hill, 1971.

Hines, F., Tweeten, Luther, and Redfern, Martin. "Social and Private Rates of Return to Investment in Schooling by Race-Sex Groups and Regions." Journal of Human Resources 5 (Summer 1970): 318-40.

Hopkins, Thomas D. "The Provision of Higher Education: A Market Interpretation." Unpublished Ph.D. dissertation, Yale University, 1971.

Johnson, George E. "The Demand for Labor by Educational Category." Southern Economic Journal 37 (October 1970): 190-204.

Johnston, John. Econometric Methods. 2d ed. New York: McGraw-Hill, 1971.

Lansing, John B., Lorimer, Thomas, and Moriguchi, Chikashi. How People Pay for College. Ann Arbor: Survey Research Center, Institute for Social Research, University of Michigan, 1962.

Lansing, John B., and Mueller, Eva. The Geographic Mobility of Labor. Ann Arbor: Survey Research Center, Institute for Social Research, University of Michigan, 1967.

Layard, P.R.G., Sargan, J. D., Ayer, M. E., and Jones, D. F. Qualified Manpower and Economic Performance. London: Penguin Press, 1972.

McPherson, Michael. "Public Supply and the Demand for Higher Education." Unpublished dissertation, University of Chicago, 1974.

Michael, Robert T. "Education in Non-Market Production." Journal of Political Economy 81 (March/April 1973): 306-327.

Miller, Herman P. "Annual and Lifetime Income in Relation to Education, 1939-59." American Economic Review 50 (December 1960): 962-86.

Mincer, Jacob. "The Distribution of Labor Incomes: A Survey with Special Reference to the Human Capital Approach." Journal of Economic Literature 8 (March 1970): 1-26.

Mincer, Jacob, and Polachek, Solomon. "Family Investments in Human Capital: Earnings of Women." Journal of Political Economy 82, Part II (March/April 1974): S 76-S 108.

Peltzman, Sam. "The Effect of Government Subsidies in Kind on Private Expenditures: The Case of Higher Education." Journal of Political Economy 81 (January/February 1973): 1-27.

Psacharapoulos, George. Returns to Education: An International Comparison. San Francisco: Jossey-Bass, Inc., 1973.

Rao, Potluri, and Miller, Roger LeRoy. Applied Econometrics. Los Angeles: Wadsworth Publishing Company, 1971.

Schultz, Theodore W. "Education and Economic Growth." In Henry, W. B., ed. Social Forces Influencing American Education. Chicago: National Society for the Study of Education, 1961.

Schwartz, Aba. "Interpreting the Effect of Distance on Migration." Journal of Political Economy 81 (September/October 1973): 1153-1169.

Solmon, Lewis, and Taubman, Paul. Does College Matter? New York: Academic Press, 1973.

Waud, Roger. "Man-Hour Behavior in U. S. Manufacturing: A Neoclassical Interpretation." Journal of Political Economy 76 (May/June 1968): 407-427.

APPENDIX I

DATA SOURCES, VARIABLE DEFINITIONS, DATA TABLES, AND

CORRELATION MATRICES

Data Sources

American Chamber of Commerce Researchers Association. "Cost of Living Indicators." Inter-City Index Report. Chicago, November 1970.

American Council on Education. American Universities and Colleges, 10th ed., W. Todd Furniss (ed.). Washington, 1968.

Dow Jones Investors Handbook, 1972. New York: New York Stock Exchange, 1970.

U. S. Bureau of the Census. Annual Survey of Manufacturers, 1970. "Book Value of Fixed Assets and Rental Payments for Buildings and Equipment." M70(AS)-7. Washington: Government Printing Office, 1972.

__________. Annual Survey of Manufacturers, 1970. "Statistics for Divisions and States." parts 1-9. M70(AS)-6.1-6.9. Washington: Government Printing Office, 1972.

__________. Census of Population, 1950. Vol. IV: Special Reports. Part 5, Chapter B. "Education." Table 12. Washington: Government Printing Office, 1953.

__________. Census of Population, 1960. Vol. 1: Characteristics of the Population, parts 2-52. Tables 94, 138, 139. Washington: Government Printing Office, 1963.

__________. Census of Population, 1960. Vol. 2: Subject Reports. PC(2)-3A. "Women by Number of Children Ever Born." Table 50. Washington: Government Printing Office, 1964.

U. S. Bureau of the Census. Census of Population, 1960. Vol. 2: Subject Reports. PC(2)-7F. "Industrial Characteristics." Table 21. Washington: Government Printing Office, 1967.

__________. Census of Population, 1960. Vol. 2: Subject Reports. PC(2)-2B. "Mobility for States and State Economic Areas." Table 24. Washington: Government Printing Office, 1963.

__________. Census of Population, 1960. Vol. 2: Subject Reports. PC(2)-5A. "School Enrollment." Table 10. Washington: Government Printing Office, 1964.

__________. Census of Population, 1960. Vol. 2: Subject Reports. PC(2)-5B. "Educational Attainment." Table 6. Washington: Government Printing Office, 1963.

__________. Census of Population, 1970. Vol. 1: Characteristics of the Population, parts 2-52. Tables 164, 197. Washington: Government Printing Ofiice, 1973.

__________. Census of Population, 1970. Vol. 2: Subject Reports. PC(2)-5B. "Educational Attainments." Table 7. Wahington: Government Printing Office, 1973.

__________. Current Population Reports. Series P20. Population Characteristics. No. 156. "Mobility of the Population of the U. S." Table 5. Washington: Government Printing Office, 1966.

__________. Current Population Reports. Series P25. Population Estimates and Projections. No. 460. "Preliminary Intercensal Estimate of States and Components of Population Change, 1960 to 1970." Table 7. Washington: Government Printing Office, 1971.

__________. Current Population Reports. Series P60. Consumer Income. No. 75. "Money Income in 1969 of Families and Persons in the United States." Washington: Government Printing Office, December 1970; Also Nos. 80, 85, and 90 (of the same title for years 1971, 1972, and 1973); Also No. 74. "Annual Mean Income, Lifetime Income, and Educational Attainment of Men in the U. S., for Selected Years, 1956-68." October 1970.

U. S. Bureau of the Census. Statistical Abstract of the U.S., 1962. Table 431. Washington: Government Printing Office, 1962. Also 1973 edition. Table 577.

U. S. Bureau of Labor Statistics. Handbook of Labor Statistics, 1971. Table 130. Washington: Government Printing Office, 1972.

__________. Special Labor Force Report. No. 125. "Educational Attainment of Workers, March 1970." Table C and Table K. Washington: Government Printing Office, 1970.

U. S. Office of Education. Biennial Survey of Education in the U.S., 1948-50. Part 4. "Statistics of Higher Education, 1949-50." Washington: Government Printing Office, 1956.

__________. "Financial Statistics of Institutions of Higher Education 1959-60." Circular No. 744, OE 50023-60. Table I. Washington: Government Printing Office, 1964.

__________. "Opening (Fall) Enrollment in Institutions of Higher Education, 1960." Circular No. 652. OE 54007-60. Table 3.

__________. National Center for Educational Statistics. "Financial Statistics of Institutions of Higher Education, Current Funds Revenue and Expenditures 1968-69." OE 52010-69. Tables 3 and 4. Washington: Government Printing Office, 1970.

__________. __________. "Fall Enrollment in Higher Education, 1969, Supplementary Information." (OE) 72-6. Table 5. Washington: Government Printing Office, 1970.

__________. __________. "Financial Statistics of Institutions of Higher Education: Student Financial Aid 1965-66." OE 52011-66. Table 5. Washington: Government Printing Office, 1968.

__________. __________. Digest of Educational Statistics, 1965. OE 10024-65. Washington: Government Printing Office, 1966.

__________. __________. "Residence and Migration of College Students, Fall 1968." Washington: Government Printing Office, 1970.

U. S. Internal Revenue Service. Statistics of Income, 1965. "Business Income Tax Returns." Washington: Government Printing Office, 1967.

Variable Definitions

L_i^* = the share of white males (females) age 25-34 with income who have i=16 or more years of school completed, 1970.

L_i = the share of white males (females) age 25 or more years with income who have i=16 or more years of school completed, 1970 (L_{it_o}) and 1960 (L_{it_o-n}).

ΔL_i = $L_{it_o} - L_{it_o-n}$

BEN = the expected private market benefit of a college education investment:

theoretically specified as $\sum_{t=m+1}^{k} \frac{W_{it} - W_{jt}}{(1+r)^t}$

where W_{it}, W_{jt} = earnings of college and high school educated workers in year t, r=discount rate, m=the number of years of college education, and k=the length of the working life;

empirically specified as $(W_i - W_j)\left[\frac{1}{r} - \sum_{t=1}^{m} \frac{1}{(1+r)^t}\right](1-\rho)$

where W_i, W_j = median annual income of white males (females) age 25 or more years with income who have i=16 or more and j=12 years of school completed, deflated by P, the state absolute price level index (calculated as a population-weighted average of 40 metropolitan areas and four non-metropolitan regions for 1970), 1959; r=the discount rate calculated as a weighted average of the return to debt and equity instruments and return to sales of proprietorships and partnerships, adjusted for the subjective rate of time preference (indicated by personal income per capita), 1960; m=4 or more years (see above); ρ=the involuntary college drop-out rate, indicated by degrees granted relative to prior freshman enrollment.

COST = the expected private costs of college education, which is foregone earnings plus direct costs:

theoretically specified as $\sum_{t=1}^{m} \frac{W_{jt}-W_{it}^{pt}+DC_{it}}{(1+r)^t}$

where W_{jt} = earnings of high school educated workers in year t; W_{it}^{pt} = part-time earnings of college students in year t, and DC_i = direct costs of college;

empirically specified as $\sum_{t=1}^{m} \frac{W_j-W_i^{pt} + DC_{it}}{(1+r)^t} \cdot (1-p)$

where W_j = median annual income of white males (females) age 18-24 with income who have j=12 years of school completed, deflated by P, 1959; W_i^{pt} = mean annual part-time income of enrolled college males (females) age 16-24 years, 1959; DC_i = revenues from student tuition and fees plus aid, per enrolled student, for four year institutions of higher education, deflated by P, 1959.

NR = BEN - COST

HS = the share of white male (female) high school graduates in the population age 17, 1960.

Y = median annual family income of husband-wife families whose head of household is age 35-44 years old and who have children age 18 or under, deflated by P, 1959.

LOAN = government loan funds disbursed per enrolled student by four-year institutions of higher education, deflated by P, 1965-66.

Q = the quality of schooling, indicated alternatively by (1) the acceptance rate of applications for admission to four-year institutions of higher education, 1966; (2) private enrollment as a share of total enrollment, 1960; (3) the Gossman "attractive" index, 1966 (see p.).

BEN (Female) = differs from BEN in that W_i and W_j are adjusted downward by EXP_i and EXP_j, where EXP_i and EXP_j = share of childless college and high school educated white females age 25 or more years.

BENREG=the benefit of college under the regional migration hypothesis,

calculated as $\sum_{z=1}^{48} \sum_{t=m+1}^{k} \phi_z \frac{W_{it}-W_{jt}}{(1+r)^t}$

where ϕ_z= the probability of migrating to the z^{th} state, calculated as the percent of males age 25-34 in the state who migrated to the z^{th} state in a single year about 1960, and z = an index over states.

BENNAT=the benefit of college under the hypothesis of a national labor market for L_i^*,

calculated as $$\sum_{t=m+1}^{k} \frac{\overline{W}_{it}-W_{jt}}{(1+r)^t}$$

where $\overline{W}$ = U. S. median value of W_i

Demand Equation Variables

L_i^* = as defined above

L_i = as defined above

W_i^*, W_j^*=median annual income of white males (females) age 25-34 with income who have i=16 or more and j=12 years of school completed, adjusted by the unemployment rate and the extent of part time working for college and high school educated workers age 25-34 in order to approximate rates of pay, deflated by P, 1969.

W_i, W_j=as above, for age 25 or more years.

R = the price of physical capital, indicated by gross rate of return to physical capital in the manufacturing sector, calculated as value added minus payroll divided by book value of depreciable assets, average of 1969 and 1970, deflated by P.

α_i/α_j= an indicator for the industrial composition of output, which is the ratio of the production coefficients of L_i^* and L_j^*,

calculated as $$\frac{L_i^*}{L_j^*} \cdot \frac{W_i^*}{W_j^*}$$

I_1, I_2... = a series of industry variables, which is the share of employment in the following industries for white males:

I_1 = agriculture, forestry, and fisheries, plus coal mining, plus textile mill products;

I_2 = two durable goods manufacturing industries: electrical machinery, equipment, and supplies, plus professional and photographic equipment and watches;

I_6 = three finance, insurance, and real estate industries: banking, plus credit agencies, plus securities, commodity brokerage, and investment companies;

I_7 = two other finance, insurance, and real estate industries: insurance, plus real estate ;

I_{13} = two public administration industries: postal service, plus federal public administration;

I_{14} = two other public administration industries: state public administration, plus local public administration

for white females:

I_2 = four non-durable goods manufacturing industries: tobacco manufacturers, plus textile mill products, plus apparel and other fabricated textile mill products, plus leather and leather products;

I_3 = three transportation industries: air transportation, plus petroleum and natural gas pipelines, plus services incidental to transportation; plus one communications industry: radio broadcasting and television; plus four utilities and sanitary services industries: electric light and power, plus electric gas and steam supply systems, plus water supply;

I_4 = finance, insurance, and real estate;

I_6 = elementary and secondary schools;

I_7 = colleges and universities;

I_9 = federal public administration.

Q = the quality of workers, as defined above.

TABLE 15. Zero order correlation matrices of variables in equations for the supply and demand for college educated white males, states of the U.S., 1970

A. Supply Variables

	ΔL_i	BEN	COST	NR	HS	Y	LOAN	Q
$L^*_{it_o}$	.859	.506	ns	.531	.472	.506	-.294	-.265
ΔL_i		.546	ns	.576	.324	.508	-.386	-.273
BEN			.412	.993	ns	.651	-.661	-.499
COST				.299	ns	ns	-.207	-.596
NR					ns	.660	-.665	-.443
HS						.378	ns	ns
Y							-.636	ns
LOAN								.336

B. Demand Variables

	$W^*_{it_o}$	$W^*_{jt_o}$	R	α_i/α_j	I_1	I_2	I_6	I_7	I_{13}	I_{14}
$L^*_{it_o}$	ns	ns	ns	.842	-.208	ns	ns	ns	.225	ns
$W^*_{it_o}$		.556	-.282	ns	-.271	.206	ns	ns	ns	ns
$W^*_{jt_o}$			-.316	ns	-.226	.240	ns	ns	ns	ns
R				ns	.433	ns	ns	ns	ns	ns
α_i/α_j					-.304	ns	ns	ns	.241	ns
I_1						.446	.698	.710	.564	.714
I_2							.803	.809	.572	.782
I_6								.978	.778	.970
I_7									.800	.979
I_{13}										.807

NOTES:
See page 178 for variable definitions.
ns indicates not statistically significant at the .10 level for a one-tailed test.

TABLE 16. Zero order correlation matrices of variables in equations for the supply and demand for college educated white females, states of the U.S., 1970

A. Supply Variables

	AL_i	BEN	COST	NR	HS	Y	LOAN	Q
L^*_{ito}	.690	.376	.313	.300	.551	.517	-.286	-.296
AL_i		ns	ns	ns	.664	.352	ns	ns
BEN			ns	.974	.208	.676	-.446	ns
COST				ns	.216	ns	-.331	-.755
NR					ns	.641	-.366	ns
HS						.344	ns	-.207
Y							-.637	ns
LOAN								.335

B. Demand Variables

	W^*_{ito}	W^*_{jto}	R	α_i/α_j	I_2	I_3	I_4	I_6	I_7	I_9
L^*_{ito}	ns	ns	ns	.920	-.512	.347	.640	.439	.257	ns
W^*_{ito}		.665	-.238	ns	.216	ns	.206	ns	ns	ns
W^*_{jto}			-.257	ns	.426	.232	.355	-.594	-.440	.206
R				ns	ns	ns	ns	.378	ns	ns
α_i/α_j					-.484	.356	.515	.513	.397	ns
I_2						-.271	-.361	-.654	-.510	ns
I_3							.580	ns	ns	ns
I_4								ns	ns	ns
I_6									.570	ns
I_7										ns

NOTES:

See page 178 for variable definitions.

ns indicates not statistically significant at the .10 level for a one-tailed test.

TABLE 17. Data for basic supply equation variables for college educated white males, states of the U.S., 1970

Variable[a] State	L^*_{ito} %	L_i %	BEN $	COST $	NR $	HS %	Y $	LOAN $	Q %
Alabama	15.7	3.1	15509	7115	8394	65.0	6268	90	80
Arizona	21.2	4.9	17350	6210	11140	85.0	6632	68	76
Arkansas	14.1	2.3	6552	6226	326	77.2	5516	130	90
California	22.3	4.9	27353	6694	20658	99.0	7762	97	69
Colorado	25.8	5.6	15849	7635	8214	75.7	7119	99	56
Connecticut	25.2	5.7	23358	7557	15800	94.5	7060	76	42
Delaware	23.6	3.8	21128	7283	13845	90.0	7570	40	31
Florida	18.5	3.3	14472	6841	7631	75.3	6338	105	66
Georgia	18.7	2.7	19108	7793	11315	63.4	6705	97	67
Idaho	18.6	3.6	10789	5778	5011	84.0	6779	104	76
Illinois	21.6	4.1	24000	7933	16067	73.0	7605	77	61
Indiana	15.3	2.7	16185	9026	7159	87.9	7017	96	74
Iowa	17.8	2.8	10212	7884	2329	93.0	6304	149	71
Kansas	22.8	4.2	12959	6373	6587	94.5	6901	119	85
Kentucky	13.8	2.7	6997	6412	585	63.6	5820	121	76
Louisiana	18.9	3.1	16021	6762	9259	76.1	6921	73	85
Maine	14.1	3.5	10551	8519	2031	78.0	5841	107	53
Maryland	26.4	6.6	32605	7089	25516	85.5	7654	62	61
Massachusetts	24.9	4.7	14672	8160	6513	90.0	6416	119	41
Michigan	18.7	3.6	22908	8517	14391	90.6	7480	87	61
Minnesota	22.5	4.4	12299	7300	4999	99.5	6776	109	89
Mississippi	17.2	3.1	10393	6549	3844	57.8	6077	156	89
Missouri	19.3	3.6	12825	7191	5634	82.0	6662	91	81
Montana	21.4	4.1	10852	6151	4702	90.4	6718	79	81
Nebraska	19.8	3.3	11046	6559	4487	94.0	6188	85	90

TABLE 17. Continued

Nevada	16.8	3.6	18605	6012	12592	95.0	7891	42	84
New Jersey	24.7	4.9	30719	7648	23071	98.7	7250	49	50
New Mexico	21.5	4.3	22582	6537	16045	75.0	7196	73	85
New York	24.3	4.1	26373	7916	18457	95.2	6543	61	49
North Carolina	15.3	3.0	14282	7179	7103	64.6	5845	115	64
North Dakota	20.7	3.4	6653	5671	982	92.5	5616	189	85
Ohio	17.3	3.0	20188	8057	12131	94.0	7186	63	69
Oklahoma	19.7	3.3	13091	6155	6936	84.4	6441	120	89
Oregon	21.3	4.3	9735	6623	3112	99.5	6974	95	83
Pennsylvania	18.3	3.1	23907	8742	15165	86.0	6336	86	53
Rhode Island	19.2	4.0	13539	7201	6338	74.9	5906	89	32
South Carolina	15.0	3.0	14969	6743	8226	54.3	6562	76	59
South Dakota	19.2	3.3	8481	6097	2384	94.2	5475	166	83
Tennesee	15.2	3.1	10328	6720	3608	68.9	6097	90	79
Texas	21.1	4.2	16265	6272	9993	66.3	6857	84	84
Utah	25.5	5.3	12956	6288	6667	88.0	7045	66	83
Virginia	23.1	5.7	26495	7012	19483	78.0	6705	60	67
Washington	22.2	4.5	16080	6981	9099	97.0	7497	116	77
Wisconsin	18.7	3.7	11591	7060	4531	99.5	6922	96	86
Wyoming	20.7	3.8	15221	6941	8280	99.5	7345	98	86
Mean	20.0	3.9	16179	7054	9125	83.8	6707	95	71
Standard Deviation	3.4	.9	6423	815	6132	12.6	622	31	16

[a] See page 175 for definitions of variables.

TABLE 18. Data on components of supply equation variables for college educated white males, states of the U.S., 1970

State / Variable[a]	L_{ito} %	L_{ito-n} %	W_{ito-n} $	W_{jto-n} $	W_{jto-n} $	W^{pt}_{ito-n} $	DC_{ito-n} $	ρ %
Alabama	11.5	8.4	7631	5437	2713	1031	410	84
Arizona	16.5	11.6	6855	5343	2272	863	231	87
Arkansas	9.0	6.7	6607	4955	2588	983	469	77
California	17.9	13.0	7965	5975	2340	889	200	91
Colorado	18.9	13.3	7487	5664	2347	892	502	93
Connecticut	18.5	12.8	8008	5384	2317	880	497	92
Delaware	19.2	15.4	9480	5631	2439	927	363	93
Florida	14.4	11.1	6473	4808	2239	851	393	93
Georgia	13.6	10.9	7965	5436	2589	984	530	91
Idaho	12.6	9.0	7006	5456	2418	919	305	77
Illinois	14.3	10.2	8215	5931	2663	1012	396	90
Indiana	11.0	8.3	7613	5683	2958	1124	607	89
Iowa	11.0	8.2	7065	5188	2619	995	567	88
Kansas	14.5	10.3	7348	5417	2441	928	320	84
Kentucky	9.1	6.4	7336	5493	2687	1021	369	81
Louisiana	13.7	10.6	8033	5937	2793	1062	347	78
Maine	10.3	6.8	6377	4473	2225	846	810	97
Maryland	20.8	14.2	8892	5805	2478	942	402	83
Massachusetts	16.9	12.2	7334	5155	2198	835	765	93
Michigan	12.7	9.1	8252	6026	2899	1102	418	89
Minnesota	13.9	9.5	7570	5641	2603	989	453	84
Mississippi	12.3	9.2	7151	5016	2470	939	432	84
Missouri	12.0	8.4	7345	5472	2593	985	498	83
Montana	13.2	9.1	7043	5437	2421	920	365	79
Nebraska	12.0	8.7	7182	4991	2432	924	373	87

TABLE 18. Continued

Nevada	13.6	10.0	7271	5614	2652	1008	215	75
New Jersey	17.4	12.5	8345	5633	2421	920	456	90
New Mexico	16.9	12.6	8159	5919	2469	938	361	80
New York	16.6	12.5	7618	5249	2336	888	543	90
North Carolina	11.3	8.3	6996	4680	2189	832	580	91
North Dakota	10.3	6.9	6963	4998	2024	769	370	89
Ohio	12.7	9.7	8002	5780	2865	1089	496	8[illegible]
Oklahoma	13.5	10.2	7298	5317	2463	936	323	80
Oregon	14.6	10.3	6835	5580	2549	969	332	84
Pennsylvania	12.3	9.2	7733	5258	2505	952	697	91
Rhode Island	12.7	8.7	6561	4700	1835	697	623	99
South Carolina	12.7	9.7	7262	4933	2313	879	523	86
South Dakota	10.5	7.2	6557	4645	2059	782	469	87
Tennesee	10.8	7.7	7648	5533	2654	1009	450	81
Texas	15.0	10.8	7852	5634	2459	934	373	78
Utah	18.8	13.5	7042	5669	2217	842	333	87
Virginia	18.2	12.5	8485	5234	2165	823	585	85
Washington	16.1	11.6	7499	5760	2467	937	305	90
Wisconsin	12.1	8.4	7576	5721	2700	1026	455	81
Wyoming	14.1	10.3	7360	5950	2673	1016	243	87
Mean	14.0	10.1	7495	5413	2461	935	439	86
Standard Deviation	2.9	2.2	642	394	234	89	135	6

[a] See page 175 for definitions of variables

TABLE 19. Additional supply equation data for college educated white males, states of the U.S., 1970

State \ Variable[a]	r %	P	BEN_{70} $	$BENREG_1$ $	$BENREG_2$ $	BENNAT $	QENRPVT %	QGOSS	RATION %	AGE
Alabama	8.3	94	24436	13137	11940	16479	26.6	.692	19.9	1.03
Arizona	5.9	104	19555	17183	21892	19247	2.7	1.967	11.6	1.19
Arkansas	11.7	89	12806	8670	11962	12891	28.5	.442	17.0	1.10
California	5.3	103	32423	18545	13919	15317	23.4	7.521	5.7	1.22
Colorado	7.7	95	18404	18010	18994	17589	21.4	2.223	19.3	1.14
Caonnecticut	7.5	108	23959	18206	17396	12256	61.4	.446	38.1	1.09
Delaware	10.7	101	17808	24929	25169	8776	13.5	.145	49.6	.93
Florida	7.7	102	25782	17390	22281	20438	37.1	1.260	19.8	1.09
Georgia	8.4	91	25967	15138	12644	19556	22.6	.901	21.5	1.01
Idaho	7.9	94	11115	9925	11537	16092	10.2	.467	32.6	1.12
Illinois	6.5	101	22398	19436	16496	13649	43.6	1.206	22.1	1.05
Indiana	7.7	99	15126	16709	16853	14194	38.1	1.745	16.4	1.05
Iowa	10.4	95	9514	12157	15813	13592	50.2	1.497	25.6	1.10
Kansas	8.7	94	16522	14396	15980	15780	16.5	1.243	17.4	1.14
Kentucky	12.4	91	9763	9093	9673	9608	36.5	.857	18.2	1.04
Louisiana	7.5	92	19851	16908	14474	15289	26.5	.618	9.1	1.07
Maine	10.9	99	12515	9720	13227	16086	37.8	.312	34.8	.99
Maryland	6.1	100	29542	22282	18238	15611	41.9	.388	30.9	.96
Massachusetts	9.3	105	15455	15768	14075	12114	83.8	3.002	21.2	1.26
Michigan	6.6	99	19654	19933	15802	13893	18.6	1.496	10.4	1.12
Minnesota	9.0	96	13534	11998	11887	12532	28.4	1.008	16.1	1.11
Mississippi	10.8	87	14553	10956	15060	16451	14.7	.737	12.6	.85
Missouri	8.5	96	15457	12357	13318	14615	33.1	1.587	20.7	1.06
Montana	8.3	95	8129	11410	13809	15198	14.8	.503	22.6	1.02
Nebraska	10.8	93	11474	12631	17336	14424	28.1	.838	17.7	1.04

TABLE 19. Continued

Nevada	5.4	104	28290	17335	19378	15797	.1	.149	30.4	1.02
New Jersey	6.2	105	36535	15077	12110	14966	54.9	.425	42.9	1.06
New Mexico	6.1	95	29012	16770	15598	17817	5.3	1.102	22.9	.98
New York	6.2	108	34672	19311	20816	16836	68.7	2.647	20.5	1.10
North Carolina	9.7	94	18894	15473	18544	19045	32.8	1.173	13.0	.98
North Dakota	14.0	93	5743	10068	13484	9659	3.7	.509	22.0	.98
Ohio	6.9	101	18218	17117	14683	13171	45.1	1.418	16.7	1.08
Oklahoma	8.5	95	18023	11972	14708	15658	16.6	1.099	11.2	1.13
Oregon	7.8	100	8261	14091	16175	13357	23.2	1.523	17.8	1.16
Pennsylvania	7.0	101	25754	19216	20702	19048	76.6	1.728	22.4	.94
Rhode Island	9.2	106	15440	12904	16456	15920	60.1	.215	33.4	1.04
South Carolina	9.1	92	20012	14952	15818	19307	45.1	.661	24.2	.90
South Dakota	11.8	94	9344	8954	13335	13848	28.4	.434	22.9	1.02
Tennessee	10.5	90	16791	11456	11085	12601	40.0	1.217	17.5	1.07
Texas	7.7	93	22259	14301	14189	16265	22.8	2.342	7.3	1.06
Utah	6.9	96	6458	16159	14024	18283	35.8	1.389	7.9	1.27
Virginia	7.6	99	24107	15523	16555	17455	31.4	.765	35.9	.89
Washington	7.2	100	15914	16126	16598	14258	22.3	1.667	13.2	1.30
Wisconsin	8.9	97	8970	14434	14984	11288	30.7	1.402	16.5	1.01
Wyoming	6.2	94	11855	16548	14260	19632	.1	.444	32.7	1.24
Mean	8.4	98	18229	14933	15628	15246	31.2	1.231	21.4	1.07
Standard Deviation	2.0	5	7630	3631	3213	2785	19.3	1.170	9.6	.10

[a] See page 175 for definitions of variables

TABLE 20. Data for the demand equation variables for college educated white males, states of the U.S., 1970

State Variable[a]	W^*_{ito} \$	W^*_{jto} \$	W_{ito} \$	W_{jto} \$	R %	$(\alpha i/\alpha j)*i/j$		I_1 %	I_2 %	I_6 %	I_7 %	I_{13} %	I_{14} %
Alabama	12149	8862	14126	9295	40.6	.564	.669	9.2	1.2	1.1	2.2	3.3	2.7
Arizona	10105	8658	11664	8981	73.6	.738	.777	4.2	3.8	1.7	3.4	3.9	3.2
Arkansas	11636	8602	11784	8442	80.8	.494	.511	12.0	2.5	1.0	2.0	2.4	2.0
California	11581	9583	13976	10346	63.1	.873	.893	3.6	3.3	1.7	3.2	3.6	3.5
Colorado	10882	9083	13119	9616	63.1	.883	.883	7.2	1.9	1.7	3.0	4.3	2.7
Connecticut	12014	9559	14381	10212	55.5	.943	1.005	2.4	4.6	1.5	3.3	1.7	2.7
Delaware	12362	9253	15416	10167	23.3	.812	1.031	4.3	.8	1.5	2.1	2.5	2.3
Florida	11321	8526	11816	8146	57.9	.679	.763	4.4	2.0	1.5	2.9	3.7	3.5
Georgia	12896	9609	14587	9937	60.5	.718	.889	11.4	1.3	1.5	2.9	4.3	2.5
Idaho	10270	9085	11725	9343	53.3	.569	.536	18.0	.2	1.0	1.9	2.6	2.6
Illinois	12135	10287	14383	10895	57.3	.686	.668	4.9	4.8	1.6	2.6	1.9	2.4
Indiana	11600	10065	13674	10424	41.5	.406	.436	5.4	5.5	1.1	1.9	1.8	1.8
Iowa	11087	9645	12935	9737	72.4	.426	.426	19.6	2.1	1.1	2.2	1.8	2.1
Kansas	11177	8941	12790	9307	73.4	.714	.634	13.7	.8	1.3	2.4	2.6	2.3
Kentucky	11809	9682	12993	9842	80.7	.518	.571	13.6	3.7	1.0	1.8	2.5	2.1
Louisiana	12132	9868	13728	10254	35.8	.633	.727	4.9	.6	1.5	2.5	2.1	3.1
Maine	9896	7894	11284	8015	40.7	.423	.467	8.9	1.2	.9	1.7	2.8	2.7
Maryland	12240	9637	15913	10583	42.0	.974	1.295	3.0	2.8	1.4	2.7	11.2	3.2
Massachusetts	10926	8947	13097	9364	74.0	.901	.818	2.7	6.2	1.6	2.7	2.8	3.4
Michigan	12884	11401	15222	11910	44.4	.550	.565	2.7	1.6	1.0	1.9	1.4	2.3
Minnesota	11774	9957	13932	10593	75.8	.626	.632	11.4	2.2	1.3	2.2	2.1	2.1
Mississippi	11709	8934	12632	8915	64.1	.627	.655	8.8	1.7	1.2	2.0	3.1	2.7
Missouri	11405	9407	13437	9781	74.7	.591	.606	8.3	2.5	1.3	2.3	2.9	3.0
Montana	9718	8939	11439	9353	35.4	.694	.544	18.8	.1	1.1	1.9	3.2	2.7
Nebraska	10872	8830	12511	9053	94.5	.540	.505	21.2	1.5	1.3	2.7	2.4	2.3

TABLE 20. Continued

Nevada	11566	9333	12325	9616	42.5	.518	.510	3.4	.4	1.2	1.9	3.9	3.7
New Jersey	12875	9990	14994	10335	58.8	.919	.952	2.1	5.3	2.2	3.0	2.8	3.0
New Mexico	10953	8311	12828	9027	53.2	.836	.916	7.0	.8	1.4	2.6	5.9	2.1
New York	12107	9194	13907	9531	68.6	.961	.919	2.6	4.8	3.1	3.0	2.5	3.6
North Carolina	11239	8292	12911	8687	73.2	.574	.814	18.2	2.2	1.0	2.1	2.1	2.2
North Dakota	9905	8529	11798	8718	137.2	.652	.592	31.4	.1	1.1	1.7	3.2	2.4
Ohio	11933	10213	14153	10676	48.5	.487	.544	3.5	11.0	1.0	2.0	2.2	2.1
Oklahoma	11073	8552	12330	8831	52.4	.682	.722	8.3	1.3	1.2	2.2	6.1	2.6
Oregon	10114	9572	11982	9957	47.0	.616	.615	7.2	1.5	1.3	2.5	2.2	3.0
Pennsylvania	11323	8883	13529	9381	44.8	.533	.587	4.5	4.1	1.2	2.1	2.6	2.2
Rhode Island	10155	8278	12061	8815	64.6	.668	.703	5.8	3.1	1.3	2.1	4.6	3.1
South Carolina	11782	8763	13504	9304	45.0	.548	.831	20.3	1.4	1.0	2.5	2.8	2.1
South Dakota	9850	7954	113[illegible]6	8312	93.5	.558	.526	32.2	.3	1.8	1.7	2.8	2.3
Tennesee	12350	9112	13946	9505	66.3	.587	.667	8.5	2.2	1.2	2.3	2.1	2.3
Texas	12236	9388	14102	10011	47.1	.893	.963	6.3	1.9	1.5	3.0	3.4	2.5
Utah	9350	9076	11967	10117	80.4	.812	.760	6.0	.9	1.3	2.1	10.5	2.5
Virginia	11547	8824	14722	9271	57.6	.944	1.271	8.2	1.8	1.3	2.5	11.2	2.6
Washington	11176	9993	13489	10811	30.9	.673	.662	5.8	.7	1.3	2.9	3.1	2.9
Wisconsin	11062	9983	13363	10528	63.2	.465	.511	9.4	3.4	.9	1.9	1.5	2.8
Wyoming	10116	9394	12246	9811	31.2	.590	.561	14.9	.3	1.0	1.6	3.4	3.0
Mean	11318	9220	13202	9639	60.1	.669	.714	10.9	2.8	1.5	2.7	3.9	3.0
Standard Deviation	907	686	1175	807	20.1	.161	.204						

[a] See Tables 17 and 18 for data on L^*_{ito} and L_{ito}. See page 175 for definitions of variables.

TABLE 21. Data for basic supply equation variables for college educated white females, states of the U.S., 1970

State \ Variable[a]	L^*_{ito}	L_i	BEN	COST	NR	HS
Alabama	11.5	1.2	9620	5279	4341	70.3
Arizona	16.2	2.0	21675	4818	16857	84.1
Arkansas	10.6	1.2	6.79	4570	1609	79.3
California	17.7	2.5	19961	5718	14243	99.5
Colorado	21.6	3.2	14382	4679	9703	81.2
Connecticut	20.7	3.3	11394	7202	4192	99.5
Delaware	17.3	2.5	9079	6111	2969	96.9
Florida	14.1	1.5	13508	5863	7645	84.6
Georgia	13.8	1.9	9957	6509	3448	72.9
Idaho	11.4	2.3	13500	3718	9782	85.6
Illinois	17.5	2.5	16995	6923	10072	89.4
Indiana	12.6	1.3	15434	6866	8568	86.0
Iowa	15.4	2.5	8202	5701	2502	92.0
Kansas	18.0	2.4	11053	4859	6194	94.5
Kentucky	12.1	1.9	4801	5028	-227	75.6
Louisiana	17.2	1.9	15351	4944	10407	80.8
Maine	10.6	2.6	8316	6417	1899	83.9
Maryland	20.3	3.6	15737	6770	8967	90.2
Massachusetts	21.2	3.1	9195	7754	1441	99.5
Michigan	16.6	2.1	21862	7100	14762	90.6
Minnesota	18.2	2.7	9590	5950	3640	99.5
Mississippi	12.9	1.2	7975	4451	3524	67.8
Missouri	15.1	2.1	9622	6050	3573	80.9
Montana	17.0	4.3	10768	4450	6318	90.4
Nebraska	15.6	2.4	7338	4884	2454	99.5

TABLE 21. Continued

Nevada	13.8	2.5	17419	4614	12805	99.6
New Jersey	18.9	2.6	14928	7451	7476	99.5
New Mexico	16.4	1.6	22917	5184	17733	76.4
New York	22.2	2.6	17463	8051	9412	96.0
North Carolina	11.6	1.1	9014	6041	2973	70.8
North Dakota	15.5	2.6	6154	4480	1674	94.2
Ohio	14.6	1.9	15260	6602	8658	88.8
Oklahoma	13.7	1.0	14903	4606	10297	83.5
Oregon	16.8	2.5	13255	4528	8727	99.5
Pennsylvania	14.7	1.8	15861	7935	7926	96.0
Rhode Island	14.2	2.0	11459	7153	4306	93.7
South Carolina	11.1	.9	6171	5855	316	71.8
South Dakota	14.6	2.8	7855	4712	3143	94.2
Tennesee	11.0	1.2	7269	5260	2009	74.8
Texas	15.3	1.6	15092	5230	9862	70.7
Utah	17.0	2.1	16633	4299	12334	83.5
Virginia	17.5	2.5	10033	6622	3410	75.0
Washington	17.9	2.8	15885	5251	10634	99.5
Wisconsin	16.6	2.8	9120	5660	3460	99.5
Wyoming	16.7	3.3	24412	4105	20307	95.0
Mean	15.7	2.2	12724	5694	7030	87.5
Standard Deviation	3.0	.7	4877	1126	4938	10.1

[a] See page 175 for definitions of variables. See Table 17 for data on Y, LOAN, and Q.

TABLE 22. Additional supply equation data fcr college educated white females, states of the U.S., 1970

State \ Variable[a]	L_{it_o}	L_{it_o-n}	W_{it_o-n}	W_{jt_o-n}	W_{jt_o-n}	$W^{pt}_{it_o-n}$	P	BENFEM	BENOCC	BENMALE	EXP_i	EXP_j
Alabama	8.5	7.3	3657	2297	1689	473	84	7383	12287	12260	59	53
Arizona	12.2	10.2	3946	2035	1517	425	86	15729	19599	15029	59	52
Arkansas	7.1	5.9	3588	1872	1399	392	81	5076	4800	5653	59	52
California	11.6	9.1	4045	2508	1905	534	86	15529	23993	21341	61	53
Colorado	13.4	10.2	3679	2059	1112	311	92	10952	13854	13069	59	52
Connecticut	11.3	8.0	3612	2359	1929	540	94	8773	13662	17629	59	54
Delaware	11.2	8.7	3934	2297	1774	497	94	7154	12650	16162	59	54
Florida	9.5	8.0	3400	1863	1611	451	94	10435	13783	12066	61	54
Georgia	9.3	7.4	3771	2454	1841	515	91	7996	12859	14816	59	52
Idaho	8.8	6.5	3520	1581	1265	354	77	8849	9084	9356	54	48
Illinois	9.2	6.7	4095	2459	2074	581	89	14919	15308	19008	65	54
Indiana	7.8	6.5	4074	2227	1746	489	90	12371	14828	13964	61	52
Iowa	8.9	6.4	3186	1695	1511	423	89	6721	7442	8535	60	50
Kansas	10.7	8.3	3545	1898	1588	445	84	8610	9769	10779	59	51
Kentucky	8.0	6.1	3447	2213	1735	486	83	4661	5779	5828	63	53
Louisiana	10.8	8.9	4211	2229	1673	468	79	11541	15705	13365	59	51
Maine	7.4	4.8	3133	1601	1378	386	95	6606	6448	8824	59	52
Maryland	11.9	8.3	4061	2624	2068	579	86	12258	22972	24053	60	53
Massachusetts	10.1	7.0	3430	2118	1856	520	94	8980	11151	11452	67	55
Michigan	9.4	7.3	4403	2318	1993	558	92	17548	21423	19417	62	51
Minnesota	9.7	7.0	3461	1957	1878	526	64	8145	9639	10155	62	52
Mississippi	9.7	8.5	3436	1903	1414	396	82	6275	6925	8670	59	51
Missouri	8.4	6.3	3641	2252	1804	505	84	9149	10655	10610	66	54
Montana	11.5	7.2	3193	1694	1318	369	84	7788	8908	9108	57	49
Nebraska	9.2	6.8	3278	1779	1619	453	83	6408	5327	8864	62	50

TABLE 22. Continued

Nevada	10.2	7.7	4034	2462	1792	502	74	13420	16632	15121	61	54
New Jersey	9.4	6.8	3774	2443	2133	597	89	11815	19682	22695	61	54
New Mexico	13.3	11.7	4536	2204	1704	477	78	16416	21672	18745	59	51
New York	11.1	8.5	3998	2464	2152	603	92	15943	21948	20397	66	55
North Carolina	8.9	7.8	3704	2243	1612	451	91	6608	9051	11490	57	53
North Dakota	8.3	5.7	3243	1460	1411	395	89	5043	4271	5760	58	49
Ohio	8.7	6.8	3881	2192	1895	531	86	12339	15946	16956	62	52
Oklahoma	9.5	8.5	4162	1935	1472	412	81	10494	12202	11292	57	51
Oregon	10.7	8.2	3624	1807	1487	416	79	9787	10365	8933	58	50
Pennsylvania	7.7	5.9	3770	2181	1888	529	94	13852	18325	18554	65	54
Rhode Island	7.4	5.4	3637	2045	1744	488	98	10472	11464	11564	66	55
South Carolina	10.4	9.5	3366	2406	1696	475	89	4621	9084	11880	56	52
South Dakota	8.8	6.0	3180	1448	1269	355	89	6407	4964	7313	59	49
Tennesee	7.6	6.4	3796	2326	1701	476	82	6270	8334	8444	62	54
Texas	10.4	8.8	4125	2168	1634	458	82	10982	15555	13376	59	52
Utah	11.2	9.1	3711	1753	1471	412	76	10436	10282	10661	53	48
Virginia	11.6	9.1	3527	2338	1820	510	88	7640	17506	19564	59	54
Washington	11.3	8.5	3803	1984	1613	452	85	11976	14848	13668	59	51
Wisconsin	9.3	6.5	3367	1925	1821	510	82	8183	9199	9641	63	51
Wyoming	12.1	8.8	4103	1762	1324	371	84	16676	13954	13862	57	48
Mean	9.9	7.6	3713	2085	1674	469	86	9982	12759	13089	60	52
Standard Deviation	1.6	1.4	341	301	246	69	6	3558	5241	4662	3	2

[a] See Table 17 for data on DC, r, and P. See page 175 for definitions of variables.

TABLE 23. Data for the demand equation variables for college educated white females, states of the U.S., 1970

State \ Variable[a]	$W^*_{it_o}$ $	$W^*_{jt_o}$ $	R %	(α_i/α_j)	I_2 %	I_3 %	I_4 %	I_6 %	I_7 %	I_9 %
Alabama	6021	4404	49.6	.357	14.9	1.0	5.9	14.7	9.5	3.0
Arizona	5415	3849	73.8	.572	1.2	1.2	8.1	17.0	12.4	2.1
Arkansas	5996	4194	80.8	.347	8.8	.9	5.0	15.8	9.7	1.3
California	6761	4673	63.1	.682	1.2	1.5	8.4	18.1	10.3	1.8
Colorado	5789	3975	63.1	.815	.9	1.6	7.7	19.0	11.8	2.6
Connecticut	5814	4013	55.5	.753	3.0	.6	8.7	16.8	10.4	.4
Delaware	6016	4365	28.3	.554	4.2	.8	6.6	16.9	11.7	.9
Florida	5929	4093	57.9	.480	1.6	1.7	8.7	16.4	10.1	1.4
Georgia	6851	5087	60.5	.458	16.8	1.5	6.8	13.2	8.9	3.4
Idaho	5200	3247	58.3	.430	.3	1.0	5.6	16.5	10.7	1.6
Illinois	6311	4300	57.3	.604	1.8	1.1	7.5	16.8	8.1	1.0
Indiana	5919	4158	41.5	.397	1.8	.8	6.3	14.8	9.1	1.2
Iowa	6250	3815	72.4	.513	1.0	.8	6.2	19.4	11.3	.8
Kansas	5592	3981	73.4	.570	1.6	1.0	6.5	20.0	11.0	1.6
Kentucky	6498	4424	80.7	.455	8.8	.8	5.4	15.3	11.6	1.9
Louisiana	6307	4365	35.8	.579	1.4	1.3	7.8	18.6	12.7	1.8
Maine	6211	3444	40.7	.437	15.0	.7	4.7	16.7	9.7	.9
Maryland	6895	4939	42.0	.688	3.4	.9	7.4	16.7	10.2	9.2
Massachusetts	6088	3921	74.0	.851	6.7	.9	7.5	19.6	9.1	1.1
Michigan	6982	4592	44.4	.576	1.0	.9	7.0	19.2	11.9	.6
Minnesota	6338	3977	75.8	.605	1.8	1.1	6.3	20.5	10.2	.8
Mississippi	6325	4468	64.1	.448	15.6	.9	5.6	15.4	10.0	1.7
Missouri	6463	4354	74.7	.502	6.4	1.1	6.7	16.2	9.7	2.1
Montana	5658	3302	35.4	.691	.1	1.2	5.5	20.4	12.6	2.0
Nebraska	5905	3802	94.5	.511	.7	1.2	7.1	19.6	10.5	1.1

Table 23. Continued

Nevada	5926	4561	42.5	.406	.2	1.4	6.1	14.1	8.3	2.1
New Jersey	6056	4368	58.8	.619	5.6	.9	7.5	13.4	9.3	.8
New Mexico	6193	3865	53.2	.660	.8	1.2	6.2	18.6	15.3	4.2
New York	6838	4532	68.6	.895	5.8	2.0	9.0	17.5	10.6	.8
North Carolina	5935	4511	73.2	.360	26.6	.7	5.0	12.0	8.3	1.0
North Dakota	5175	3220	137.2	.610	.1	.7	5.3	25.0	12.7	1.7
Ohio	5911	4193	48.5	.446	1.5	.8	5.9	15.5	9.8	1.1
Oklahoma	5856	3953	52.4	.465	2.5	1.0	6.6	18.6	10.2	3.3
Oregon	5675	3838	47.0	.562	1.4	.9	7.2	19.0	10.7	1.0
Pennsylvania	6179	4086	44.8	.450	11.4	.7	6.4	16.4	9.3	1.2
Rhode Island	5956	3729	64.6	.570	8.6	.5	5.4	16.3	8.3	1.2
South Carolina	6150	4618	45.0	.375	26.5	.7	5.0	12.5	8.8	1.6
South Dakota	6148	3397	93.5	.594	.4	.8	4.6	21.8	13.1	1.5
Tennesee	6309	4640	66.3	.364	16.3	1.0	5.7	14.4	9.1	1.1
Texas	6099	4414	47.1	.564	2.5	1.2	8.5	15.9	11.8	2.1
Utah	4855	3651	80.4	.551	3.0	1.0	5.7	16.3	10.9	8.0
Virginia	6311	4649	57.6	.607	9.2	1.1	6.5	15.2	10.4	8.3
Washington	6220	4258	30.9	.626	1.1	1.5	7.9	18.9	10.1	1.6
Wisconsin	6752	3943	63.2	.575	2.8	.6	5.4	19.1	9.6	.5
Wyoming	5834	3258	31.2	.710	.2	1.2	4.8	17.4	13.6	1.7
Mean	6088	4121	60.1	.553	5.5	1.0	6.5	17.1	10.5	2.0
Standard Deviation	449	454	20.1	.132	6.7	.3	1.2	2.5	1.6	1.9

[a] See Table 20 for data on $L^*_{1t_o}$ and R. See page 175 for definitions of variables.

APPENDIX II

EVIDENCE ON THE PRIVATE RATE OF RETURN TO COLLEGE EDUCATION IN THE U.S. OVER TIME

Estimates of the private rate of return to an investment in college education have been made for the Census years 1940, 1950, and 1960, as well as a few intercensal years. The principle studies are those by Becker (1960, 1964), Schultz (1960), Hansen (1963), Hanoch (1967), Hines, Tweeten and Redfern (1970), and Carnoy and Marenbach (unpublished). Results from one study are not strictly comparable to those of another because of differences in the samples used and in the number and nature of adjustments made to the raw income or earnings data. However, the study by Carnoy and Marenbach attempted to use consistent methodology over time. The figures below are estimated private rates of return to college education marginal to high school for white males.

There is no discernable trend in the rate of return over the more than 30 year time period. Most of the estimates are in the neighborhood of 12 to 16 percent except the Hanoch figure, which resulted from more extensive earnings adjustments than in the other studies.

Year	Source	Rate (%)
1939	Becker	14.5
1939	Carnoy and Marenbach	16.3
1949	Becker	13.2
1949	Hansen	11.6
1949	Carnoy and Marenbach	12.8
1956	Becker	12.4
1958	Becker	15.0
1958	Schultz	11.0
1959	Hanoch	9.8
1959	Hines, et. al.	13.6
1959	Carnoy and Marenbach	17.6
1969	Carnoy and Marenbach	16.2

In a new compendium of work on the rate of return to education, Psacharapoulos (1973) concludes "the profitability of investment in college education in the United States did not change appreciably between 1939 and 1961." Furthermore, these rates of return are favorable. According to Hanoch (1968), they are "higher than rates of interest in the market and somewhat higher than average rates of return generally estimated for non-human capital."

Note that the long run equilibrium condition that the net return should equal zero means that the internal rate of return to education should be equal to the alternative rate of return, such as the rate of return to physical capital. In fact the measured rate of return to college education in the U.S. has been slightly above the rate of return to physical capital for 20 years. (Of course, this could be an artifact of a systematically incorrectly calculated rate of return either to human or physical capital.) This may be explained by the fact that the calculated rate of return to college education usually assumes that all earnings associated with education are due only to education and not associated factors such as ability, credentialing, SES, motivation, unemployment, and labor force participation.

APPENDIX III

PRIVATE INTERNAL RATES OF RETURN TO COLLEGE EDUCATION, 1959 AND 1969, 45 STATES OF THE U.S.

The following internal rates of return were calculated by setting BEN equal to COST and solving for the discount rate (see equation 11, p. 36, for the expression for BEN and equation 31, p. 104, for the expression for COST).

State	1959	1969
Alabama	14.4	17.9
Arizona	13.0	14.0
Arkansas	11.9	15.0
California	15.7	16.2
Colorado	13.3	16.0
Connecticut	16.8	17.0
Delaware	20.7	19.3
Florida	13.3	16.7
Georgia	15.5	17.1
Idaho	12.5	13.5
Illinois	14.9	14.7
Indiana	11.9	13.1
Iowa	12.5	13.0
Kansas	14.4	15.9
Kentucky	14.0	14.2
Louisiana	14.1	15.5
Maine	12.5	14.1
Maryland	18.4	19.2
Massachusetts	14.1	14.1
Michigan	14.0	13.5
Minnesota	13.2	14.7
Mississippi	14.6	15.4
Missouri	11.9	15.3
Montana	12.5	13.0

State	1959	1969
Nebraska	15.3	14.9
Nevada	12.8	14.3
New Jersey	19.1	17.7
New Mexico	15.5	18.4
New York	15.5	17.2
North Carolina	15.4	16.7
North Dakota	15.2	16.0
Ohio	13.7	13.7
Oklahoma	14.5	16.1
Oregon	10.5	12.5
Pennsylvania	14.8	16.2
Rhode Island	14.2	15.5
South Carolina	15.4	16.0
South Dakota	14.6	15.2
Tennesee	14.0	17.0
Texas	15.3	17.4
Utah	12.0	12.5
Virginia	18.9	19.8
Washington	13.5	14.1
Wisconsin	12.7	13.0
Wyoming	11.4	12.7

The internal rate of return exhibits some variation across states. Since in long run equilibrium one might expect the rate of return to be equal everywhere, a question arises: is the variance in 1959 rates of return due to disequilibrium, or due to nonpecuniary differences across states? The supply model of this study says that high school graduates make the college attendance decision partly on the basis of the investment value of a college education; the higher the benefits and the lower the costs, the larger the subsequent stock of college educated labor. Since this model is supported by the analysis, it would be expected that states which in 1959 had high rates of return would have larger increments to their stock of college educated labor than states with low rates of return, and that the market wages of college educated workers would thus be depressed (abstracting from demand side considerations). This would tend to reduce the 1969 rate of return in that state. In other words, a convergence toward the mean of the state internal rates of return from 1959 to 1969 would be consistent with the supply analysis in this paper. On the other hand, if there is no convergence in the rates of return, that may be taken as a sign of either a persisting disequilibrium (or perhaps that 10 years is too short an adjustment period), or as a sign of equilibrium, with the differences across states attributable to non-pecuniary factors.

Evidence on this question can be provided by the following statistics for the internal rate of return in 1959 and 1969.

Statistic	1959	1969
Mean	14.3	15.5
Range	10.2	7.3
Variance	3.996	3.618
Coefficient of Variation	.140	.123

The coefficient of variation for 1959 is small, indicating that if the 1959 rates of return are disequilibrium observations, the extent of disequilibrium is small. There is evidence of some convergence by 1969 since the range, variance, and coefficient of variation all decline by modest amounts.

APPENDIX IV

SEQUENTIAL COLLEGE EDUCATION DECISIONS AND DYNAMIC ADJUSTMENT

The supply model in this study explains the stock of young college educated labor at a single point in time, and the change in the entire stock over a ten year time span. The model is static, despite the rate of change dependent variable, insofar as the explanatory variables are measured at a single point in time.

In this appendix, an elementary inquiry is made into the nature of the dynamic adjustment of the stock of college educated labor. To do so, the outlines of a sequential college education decision model are sketched. This constitutes an extension of the reasoning which led to the specification of the basic supply equation in Chapter II.

From equation (1), page 8, the change in the number of college educated workers, L_i, from one time period to the next is

$$L_{it_o} - L_{it_o-1} = L^e_{it_o} - L^d_{it_o} \quad \text{(i)}$$

where $L^e_{it_o}$ = the number of entrants into college educated labor category L_i in period t_o, and $L^d_{it_o}$ = the number who depart from that category.

The number of entrants $L^e_{it_o}$ is given by the number of new college graduates who join the labor force and are employed,

$$L^e_{it_o} = \theta_{t_o} \quad (1-u_{t_o}) \quad G_{t_o} \tag{ii}$$

where G_{t_o} = the number of new college graduates in period t_o, θ_{t_o} = the proportion of college graduates who enter the labor force, and u = the unemployment rate. The variable θ is an individual decision variable. It is a probability whose value may change from one period to the next. For prime-age college-educated males, $\theta \doteq 1$ (and $u \doteq 0$), but for females, $\theta < 1$. The variable u is in part a firm's decision variable.[1]

By continuing to write down equations for successively earlier time periods, an expression is obtained for the cumulative number of entrants over time:

$$L^e_{i,t_o-1} = \theta_{t_o-1} \quad (1-u_{t_o-1}) \quad G_{t_o-1}$$

$$L^e_{i,t_o-2} = \theta_{t_o-2} \quad (1-u_{t_o-2}) \quad G_{t_o-2}$$

$$\sum_{t=t_o-n}^{t_o} L^e_{it} = \sum_{t=t_o-n}^{t_o} \theta_t \quad (1-u_t) \quad G_t \tag{iii}$$

The number of workers who depart from college educated labor

[1] $L^e_{it_o}$ is the increment in the stock of workers supplied to the labor force. Equation (ii) relates the increment in the stock available to the increment in the stock supplied. To obtain the increment in the flow of services supplied, variables for weeks worked per year and hours worked week would be used.

category L_i is given by the number who leave the labor force (by temporary or permanent retirement or death) or who become unemployed. An expression analogous to (iii) can be obtained for leavers.

Interest focuses on equation (iii) because $\sum_{t=t_o-n}^{t_o} L_{it}^{e}$ is the central variable in the supply model (see equation 4). Insights into the factors affecting L_i^e may suggest ways in which dynamic adjustment occurs in the stock of college educated labor. For this purpose, the college education decision is treated as a sequential decision process over the m=4 years of college attendance.[1]

The number of college graduates in year t_o, G_{t_o}, depends on the number of enrollees in year t_o-m and on the number of drop-outs each year:

$$G_{t_o} = E_{t_o-m} - \rho_{t_o-m}E_{t_o-m} - \rho_{t_o-m+1}E_{t_o-m+1} - \rho_{t_o-m+2}E_{t_o-m+2}$$

$$= E_{t_o-m} - \sum_{t=t_o-m}^{t_o-m+2} \rho_t E_t \qquad . \qquad \text{(iv)}$$

where E_t = the number of enrolled students in year t, and t = the drop-out rate in year t. The sequential decisions consist of the initial decision (as a high school graduate) to enroll

[1] To simplify, this abstracts from bachelor's degree work requiring either less than or more than four years, and it abstracts from graduate work. There is no loss of generality.

in college, and successive annual decisions whether to continue to the next year of college or drop out.

The initial decision to go to college, from the human capital based supply model, depends on the private market benefits (BEN) and costs (COST) of college, the ability to pay for college, indicated by family income (Y) and government loans (LOAN), and on the non-market quality of schooling (Q). The number of eligible high school graduates (HS) is a potential constraint on the aggregate number of college students.

$$E_t = f_t \quad (BEN_t, COST_t, Y_t, LOAN_t, Q_t) \qquad (v)$$

Drop-outs may be voluntary or involuntary. The involuntary drop-out rate depends on academic difficulties, indicated by the student's grade point average (GPA), and on financial hardships. The voluntary drop-out rate depends on unfavorable net returns from continuing in college, non-market schooling quality, and on changes in taste for college attendance (ΔT).

$$\rho_t = g_t \ (BEN_t, COST_t, Y_t, LOAN_t, Q_t, GPA_t, \Delta T_t)$$

The decision whether to continue or drop out has the same determinants as the initial enrollment decision, plus two more: GPA and ΔT.[1] Of course the values of these variables change in each period. For example, the foregone earnings component

[1] Since tastes are not measurable and there is no data by states on academic averages, these two variables would have to be deleted in an empirical analysis.

of COST for the initial enrollment decision in year t_o-m is the earnings of high school educated workers, W_{12}. For the first continuation/drop-out decision, it is the earnings of those with one year of college completed, W_{13}. BEN is formulated initially in year t_o-m as $BEN_{t_o-m} = \sum_{t=m+1}^{k} \frac{W_{16,t} - W_{12,t}}{(1+r)^t}$[1]. After one year of college, the value of BEN relevant to the continuation/drop-out decision is formulated as

$$BEN_{t_o-m+1} = \sum_{t=m-3}^{k} \frac{W_{16,t} - W_{13,t}}{(1+r)^t}$$.[2]

A sequential explanation for the number of college graduates in year t_o would proceed by taking measurements in each of the m years, t_o-m to t, on the variables common to the explanation of the initial period's enrollment and each succeeding year's drop-out rate. By repeating the sequential model, G could be explained over a span of time. This is the chief component of the number of entrants into the college

---

[1] The assumption is that prospective college students determine the benefit of completed college to make the initial enrollment decision. This is plausible since the rate of return to completed college exceeds that of one year of college. The hypothesis is that students re-evaluate their original decision at the end of each year.

[2] An alternative model could be formulated in which year's college continuation decision was a one year decision. Then the formulation above becomes

$$BEN_{t_o-m+1} = \sum_{t=m-3}^{k} \frac{W_{14,t} - W_{13,t}}{(1+r)^t}$$

educated labor category over time. The result is a dynamic model of the adjustment process for the stock of college educated labor.