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YEARS AND INTENSITY OF SCHOOLING INVESTMENT

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An essential feature of schooling is not only that it occurs in a different site than most on-the-job training but also that it is more intensive. That is, a smaller proportion of gross potential earnings is sacrificed in on-the-job training than in schooling (see Mincer, 1974). In estimating human capital earnings functions it has generally been assumed that during schooling 100% of gross potential earnings are invested in all years, while in on-the-job training this percentage is smaller and is a declining function of age. This assumption has been quite useful since it allows the identification of an estimate of the rate of return on schooling from a regression of earnings on years of schooling.

This paper argues that the percentage of gross earnings invested may fall below 100% well before schooling is ended, that this percentage is likely to be correlated with years of schooling, and thus this procedure yields only a biased estimate of the rate of return to schooling.

The rate of return is a central parameter in human capital analysis. The level of the rate of return is an index of the profitability of human capital investments (Becker, 1964), the relationship between the rate of return and the amount invested may indicate under certain conditions whether the educational process is "egalitarian" or "elitist" (Becker, 1967, p. 20).

The internal rate of return is that discount rate which equates the present value of returns from an investment to the present value of its costs. The principle of comparing the discounted value of a lifetime stream of net income with and without a marginal investment is simply stated but not so simply implemented.

Since lifetime histories of incomes of a given individual have only recently become available, cross-section data on people of various ages have been used to approximate lifetime earnings of an individual. To reduce sources of income variation other than the schooling differential being studied such estimates were usually limited to a given sex, race, urban-rural and nativity status (Becker, 1964, p. 79 and Hanoch). Adjustments have been made for the fact that business cycles have a greater effect on cross-sectional than cohort earnings (Becker, 1964, p. 73), for the sampling bias due to differential mortality experience, and for the difference in before-tax and after-tax returns.

In spite of these careful adjustments and controls there are factors which cannot be controlled for which may bias the rate of return calculations. Becker pointed out in his pathbreaking work, Human Capital, that two of these factors are the correlation between ability and education and the correlation between education and other human capital. If those who invest more in themselves are inherently more able, their earnings stream without the investment is not adequately gauged by the earnings of the person with a lower investment (and less ability). That is, some of the return imputed to human capital investments is actually a return to ability, and would have been received even without the investment. Estimates of bias to the schooling coefficient due to the omission of an ability measure, calculated by Griliches and Mason (1972), Hause (1972) and Taubman and Wales (1972) range from 3% to 25%. Becker also pointed out that his estimates of the rate of return to schooling might be seriously biased if the rate of return to other investments differed from the rate of return on schooling and if these investments were correlated.

A less laborious method of estimating rates of return from cross-section data by regressions was proposed by Becker and Chiswick (1966). This method also made possible simple controls for factors such as ability and other human capital investments. Becker and Chiswick reformulated the analysis in a way that allowed the rate of return to be estimated as a parameter in a regression where earnings was the dependent variable and the investment period was the independent variable. They let K_{ij} be the per cent of potential earnings that individual i invests in year j $(0 \leq K_{ij} \leq 1)$. Then, abstracting from depreciation, gross earnings in year t can be expressed as a function of the initial stock of human capital, E'_{oi}, the series of K_{ij} and the rate of return on these investments:

$$E_{it} = E_{oi} \prod_{j=1}^{s} (1 + K_{ij} r_{ij}) \tag{1}$$

But since $K_{ij} \leqq 1$ and r_{ij} is small, this can be written:

$$\ln E_{it} = \ln E_{oi} + \sum_{j=1}^{s} K_{ij} r_{ij} \tag{2}$$

Now, assume either that all available time is invested in schooling during the "schooling years," so that the costs are the wages foregone or, alternatively, that part-time earnings exactly offset direct schooling costs. Then $K_{ij} = 1$ for all i and j. Assuming also that r is constant over individuals and years of schooling, and that there is no post school investment,

$$\ln E_{it} = \ln E_{oi} + rs_i, \tag{3}$$

where s_i is the number of investment years where $K_{ij} = 1$.

This formulation appears to allow the estimation of the rate of return to schooling investments from the relationship of a simple function of earnings and years of schooling. A further advantage of this procedure is that it allows one to hold constant in the estimating equation other forms of capital accumulation, such as ability or post-school investment. The literature which has grown up in these two areas has indeed relied heavily on the semi-log functional form derived by Becker and Chiswick.[1]

Yet great care should be exercised in interpreting the coefficient on years of schooling as a rate of return, because of the difficulty in measuring K. Biases resulting from a mis-specified K, may as serious as those from omitting the ability variable.

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[1]See, for example, Griliches and Mason (1972), John Hause (1972) and Mincer (1974).

I. Rates of Return, Intensity and Years of Schooling

It is easy to show that even if $K_{it} = 1$ on average, unless K_{it} is independent of S, this procedure will lead to biased estimates of r.[2] Let $\bar{K}$ be the average percentage of gross earnings invested in schooling and h_{it} be the deviation from this average for the i^{th} individual in the t^{th} investment year.

$$K_{it} = \bar{K} + h_{it}$$

$$\sum_{t=1}^{S} K_{it} = S_i\bar{K} + \sum_{t=1}^{S} h_{it}.$$

Let $h_i = \frac{\sum h_{it}}{S_i}$ = the average yearly deviation in per cent of gross earnings invested per school year, for the i^{th} individual's schooling career. Then equation (3) can be rewritten:

$$\log E_{it} = \log E_{oi} + rS_i\bar{K} + \rho S_i h_i.$$

Now it is clear that if $S_i h_i$ and S_i are correlated, even a knowledge of the average percentage invested ($\bar{K}$) will not in general allow one to identify r from a regression of log earnings on years of schooling. One condition which allows the identification of the rate of return from a regression of income on years of schooling is a lack of variance in K_{it}, i.e., $h_{it} = 0$ for all i and t and $r_{ij} = r$ for all i and j.[3]

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[2]Chiswick (1974, pp. 2-13a) notes that some of the variance in income may be due to the covariance of rK and S.

[3]B. Friedman has pointed out to me that a derivation of equation (3) by Mincer (1974, see pp. 9-11) is not dependent upon the assumption of the independence of h_i and S. However, the Mincer proof requires that all individuals have identical present values of earnings.

It has been amply demonstrated in the human capital literature that there is a relationship between earnings and years of schooling. What interpretation can this relation be given? It is neither the market rental on human capital, which plays an important role in much of the theoretical analysis (e.g., Ben Porath), nor is it a rate of return on investment costs since years of schooling accurately reflect neither human capital stocks nor investment costs. To clarify these issues, consider two alternative ways of decomposing earnings of individual i in year t, E_{it}. The approaches are the market rental and rate of return calculations. In the market rental analysis earnings are the scalar product of a vector H, of quantities of various kinds of human capital possessed by an individual i at time t, and the vector of markets rents, W, available on these various kinds of capital.

$$E_{it} = \sum_{j=1}^{M} W_{tj} H_{ij}. \tag{4}$$

A perfectly competitive market for human capital services is assumed and W_{tj} does not vary across individuals.

An alternative approach is to consider the relationship between earnings and the cost of producing the stock of capital which is rented in the market. Assume a production process whereby a vector of inputs, I is transformed into a vector of human capital outputs, H. The production process is characterized by the matrix A which defines the linear transformation of input vector I into the vector of human capital outputs H. The costs per unit of input is given in the vector C.

$$H_{ij} = A\, I_{ik} \tag{5}$$

$$E_{it} = \sum_{k=1}^{N} r_{itk}\, C_{ik}\, I_{ik} \tag{6}$$

r_{itk} is the rate of return over cost for each kind of capital possessed by individual i. Assume constant returns to scale for all types of capital investments so that marginal returns equal average returns and assume also that returns are constant over time. Since an optimizing individual would equate returns on various types of capital at the margin, we can write earnings as the product of a constant rate of return on the various investments:

$$E_{it} = r_i \sum_{k=1}^{N} C_{ik} I_{ik} \qquad (7)$$

Thus r_i can be defined as the individual's rate of return over cost for his human capital investments:

$$r_i = \frac{\sum_{j=1}^{M} W_{tj} H_{ij}}{\sum_{k=1}^{N} C_{ik} I_{ik}} \qquad (8)$$

The problem in estimating equation (3) above is that years of schooling correspond most closely to a quantity of inputs I, whereas the rate of return calculation requires the denominator of equation (8) of which I is only one part. Years of schooling is equally inappropriate for estimating the market rental of human capital, W, (as in Johnson, p. 551) since the transformation of inputs into human capital outputs described by (5) is ignored.

Theory does not give a unique prediction of the relationship between years of schooling and intensity of investments per year. It is easy to show (see Ben Porath (1970)) that the proportion of resources (time and goods) that an individual allocates to investment decreases with time, after he passes the point where the size of human capital stocks is so low as to act as a binding constraint, forcing the use of less than optimal factor combinations.

If individuals faced identical marginal productivity and supply of funds schedules and they chose schooling attainment randomly, we would then expect a negative correlation between intensiveness and extensiveness of schooling investment. However, individuals are not identical, and it seems likely that some of the factors which affect the years of schooling, affect the intensity of schooling in the same direction, leading to a positive correlation between the two.[4] First consider the supply curve of funds which relates the cost of financing the investment to the intensity of the investment process in a given year of schooling.

The supply curve drawn in Figure 1 as S_1 reflects the increasing cost per unit of financing increasing intensity of investment per year of schooling. As Gary Becker has pointed out (1967, p. 9) the funds "available to any person from the cheaper sources are usually rationed since the total demand for funds tends to exceed their supply." Thus as increasing amounts of funds are required within a given year, students shift from gifts from relatives and grants from government or schools (which usually are subject to a maximum amount per school year), to subsidized loans from government or universities (also subject to a maximum amount per year). Finally they may turn to loans at commercial interest rates or to reduced consumption.

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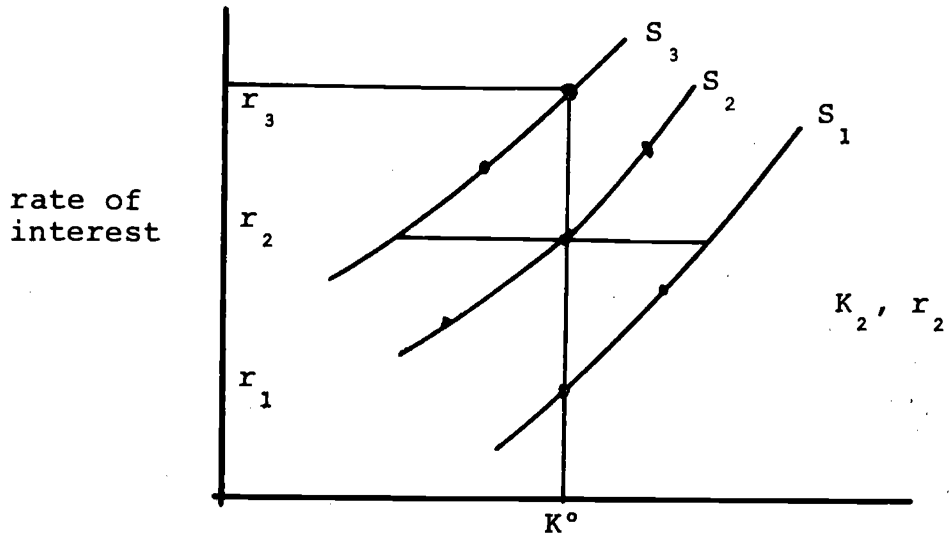
[4]Several recent papers have taken the length of the period of specialization as endogenous (Haley, Lillard, Wallance and Ihnen), but most have taken the specialization period as coincident with years of schooling. Haley is an exception. Haley considers the case where the only input to investment is time, and he shows that quantity and the proportion (K) of human capital stocks allocated to producing more human capital declines strictly monotonically, after the period of specialization when $K = 1$ (p. 934).



K = intensity of annual schooling investment
Figure 1

The interest rate required to finance schooling will not only be a function of the intensity of schooling, but also of the total number of years of schooling. Thus we can conceive of a family of supply curves corresponding to years of schooling as in Figure 1.

For several reasons it is likely that the supply curve of funds for early years of schooling lies below that for later years. First, since K is defined as the proportion of potential gross earnings invested, the dollar outlay corresponding to any given value of K, rises with schooling, which increases earnings. If the supply of funds is not completely elastic, the interest required to finance a given K rises with previous schooling level. Secondly, since the total amount invested is rising with S, the interest rate should too.

On the other hand, factors such as the greater availability of fellowships for graduate students than undergraduates may cause a reversal in the ordering of the supply curves at some point.

Next consider the relationship between the return and the intensity of investment of a marginal year of schooling. This will determine the demand for schooling intensity for one additional year. If employers looked only at years of schooling then the return would be the same for all levels of intensity as in curve AA in Figure 2.[5] But assume that greater time inputs are productive in producing human capital and that this increase in human capital is rewarded in the market. The observed marginal rate of return schedule for a year of schooling will be greater for greater intensity of the investment.

The number of units of capital produced by a person per school year, h, is a function of time and goods inputs, as well as ability.

$$h = f(I,T;A)$$

$$\frac{\partial h}{\partial I} > 0 \qquad \frac{\partial^2 h}{\partial I^2} < 0$$

$$\frac{\partial h}{\partial T} > 0 \qquad \frac{\partial^2 h}{\partial T^2} < 0$$

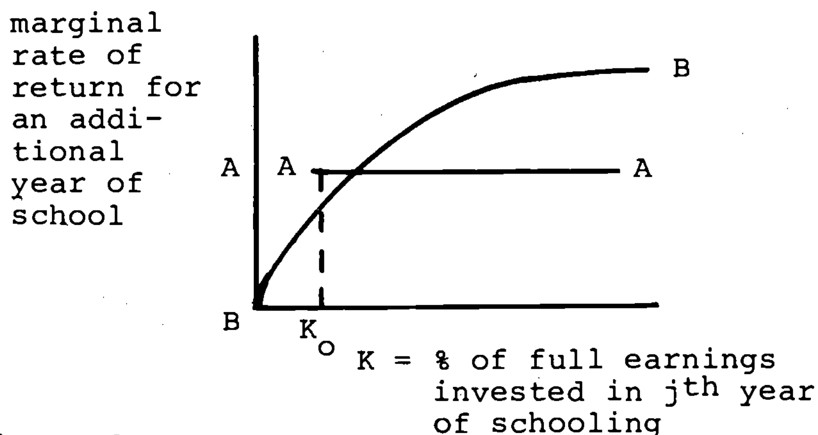


Figure 2

Although additional resources invested imply additions to the stock of human capital, because of the strict limit on the amount of time available to an individual, diminishing returns to producing additional capital will eventually set in.

Thus we can consider a family of demand curves for different intensities of schooling which relate years of schooling to marginal rates of return, as in Figure 3

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[5]This is the interpretation one can give to a rental rate on years of schooling, as in Johnson.

$i_1 < i_2 < i_3 < i_4$

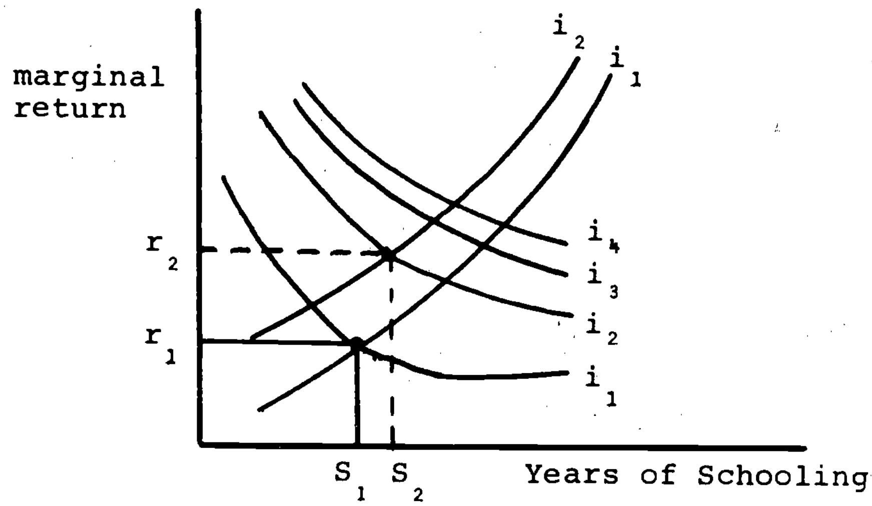

Figure 3

The supply of funds curves of Figure 1 can be aggregated for given intensities of investment to form the family of supply curves relating cost of funds to years of schooling. Then those with intensity of investment i_1 would get S_1 years of schooling and a rate of return (or borrowing cost) of r_1, while schooling intensity i_2 would be associated with S_2 and r_2. Now it is clear from Figure 3 that either positive or negative correlation between S and i is possible.

Greater ability may be said to increase the marginal productivity of any year of schooling at any given intensity. Thus if all students faced the same supply curve of funds, for an additional year of investment, we would expect more able students to invest more intensively in a given year, as well as more extensively.[6] On the supply side, too, more able students may be able to invest more per year as well as more years. More able students are more likely to obtain grants or low-cost loans from their universities or from the government, and students who score high on I.Q. tests, which measure the ability to succeed in school, come from higher income families, on average, than those who score poorly. To the extent that scholarships free a student from working or subsidize tuition they may increase the intensity of his investment in terms of time or goods, while at the same time decreasing his expenditure on schooling.

It is important to note that K need not equal unity during schooling years. Taking account of other uses of time, such as leisure, would lower the estimates of K even further. Psychologists show that even during the time that students are ostensibly learning, they may be diverting a considerable proportion of their resources to non-investment uses. (See, for example, Anderson.) These studies, using both experimental and naturalistic classroom situations find that the percentage of "time on task" (K) is positively related to the amount learned (human capital developed).

The direction of the bias in rate of return estimates made by equations of the form of equation (3) is an empirical question since there is no clear prediction about the sign of the correlation between years of schooling and intensity. Bodies of data with cost of schooling and information on earnings are rare, which is one reason for the widespread use of equation (3) as an estimating function. However, one body of data has been uncovered which can provide an illustration of some of the points raised above. This body of data referred to here as the Terman data, is described in Part 1 of the following section. In the remainder of the section the Terman data is used to estimate earnings functions from cost data.

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[6]This is true if ability has a nonneutral effect in increasing the productivity of time in investment more than in other endeavors. Haley suggests that ability might be negatively correlated with intensity if it primarily affected initial stocks of human capital, and therefore more able students could stop specializing sooner.

II. Earnings Functions Based on Cost of Investment

A. The Terman Sample

The Terman sample consists of persons whose measured I.Q. fell within the top one per cent of the I.Q. distribution when they were tested as children in 1921-22.[7] This sample of 1,528 persons with I.Q.'s of 135 and above was originally selected from the population of California school children by Lewis M. Terman, a Stanford University psychologist. Data on the earnings and schooling of these high ability individuals was updated by resurveys in 1929, 1940, 1950, and 1960.

In the 1940 questionnaire the Terman sample members were asked to supply the name of the college they attended, the amount of scholarships and assistantships they had received and their total earnings as undergraduates. We developed a tuition series for six different colleges named for the years 1921 to 1940. Of the individuals who reported cost data 95 per cent attended the six colleges for which tuition data were obtained. Cost data was supplied by 85 per cent of the sample members who attended college. Using data on age at high school graduation and age at receipt of B.A., we developed an estimate for each individual of the direct costs of his undergraduate schooling. Net indirect costs were estimated by using the data on scholarships, assistantships and earnings. Opportunity costs were estimated to be $1092 per year in 1927 dollars. This figure was arrived at by using data from Terman (III, pp. 137-138) which showed that average weekly compensation for full-time jobs in 1927 was $21 for male college students in the Terman sample and $22 for men in the sample who were not in school. However, if actual earnings

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[7] I am indebted to Dr. Robert Sears and Mrs. Meleta Oden of Stanford University for making this data available.

exceeded this estimate of opportunity costs, actual earnings were used as the measure of full-time earnings capacity. All figures were put in constant (1947) dollars, the total cost of schooling was calculated as:

Total Cost = Tuition + Opportunity Cost - Total Scholarships - Total Assistantships - Earnings.

$$\text{Then} \quad K = \frac{\text{Total Cost}}{\text{Opportunity Cost}}$$

Table 1 presents mean values for the entire sample of the cost components of undergraduate schooling as well as for K. For the entire sample with complete cost data K = .75. Table 1 indicates that the per cent of potential earnings per year invested in schooling increased with final schooling level attained.[8] For persons with less than a B.A. in 1940, the annual per cent of gross earnings potential invested in schooling, K = .55, for those with a B.A. in 1940, who had not increased their schooling level by 1950, K = .84, while those who earned advanced degrees after 1940 invested 101 per cent of gross annual earnings in their undergraduate schooling.[9] Thus, only the group who went on to graduate studies spent 100% of gross potential earnings in investment during their undergraduate years. Unfortunately, because graduate and undergraduate scholarships and assistantships awarded up to 1940 were not segregated in the data, it is not possible to calculate K for persons with graduate training before 1940. Table 1 also suggests that those who completed a higher level of schooling diverted less of their available time to the labor market during their schooling years. They earned less income, indicating either that they spent less time in the labor market or that they had lower

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[8]The anomalous result that those who did not complete their schooling until after 1940 had greater annual investments in undergraduate training than those who already had some graduate work by 1940, may be due to a cohort effect, since the former group is likely to be younger and have started to school in slightly better times.

[9]These estimates are similar to those computed by Wachtel.

Table 1

Average Components of College Costs
(1947 $)

Schooling Level in 1940:	12 < S < 16	S = 16	S = 16	S > 16
Schooling Level in 1950:		S = 16	S > 16	
Average Yearly Schooling Costs				
Tuition	176.8	223.2	285.1	247.0
Scholarships	100.4	20.1	12.9	n.a.
Assistantships	202.6	1.08	20.0	n.a.
Earnings	702.2	450.4	239.0	330.9
Opportunity Cost	1648	1485	1472	1476
K = % of Opportunity Cost Invested	.55	.84	1.01	n.a.
Number of Observations	87	134	19	248

Source: Calculated from the Terman sample.

wages. If the drop outs faced higher wages, this alone could explain their lower level of completed schooling. The sample were all of high ability, but those with high earnings potential as undergraduates would have found schooling a relatively unprofitable investment, due to their greater opportunity costs. However, it is likely that high opportunity costs drawing students out of school does not explain the situation entirely. Since students who completed more years of schooling invested more money per year in tuition, it is likely that they invested more time as well.

B. Earnings as a Function of Years and Cost of Schooling

For the subsample of individuals on whom cost data are available, we first estimate the relationship between earnings and years of schooling, in order to have a baseline with which to compare earnings functions based on costs.[10] The methodology is to combine income data from the three dates for all males on whom we had cost and income data to estimate a lifetime earning function. For this group each additional year of college increases wages by 6.9 per cent, while each year of graduate schooling (obtained after 1940) increases income by 4.7 per cent. (See Col. 1, Table 2.)

If we were to assume that years and intensity of schooling were uncorrelated, we could derive an estimate of the rate of return to schooling by dividing the schooling coefficient in equation (1) by .75, the average value of K.[11] That estimate of the rate of return is 9.2 per cent. However, since we know years of schooling and K are positively correlated, this is an overestimate, as shown above.

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[10]A subsample of 306 individuals who had no more than 16 years of schooling in 1940 was used. Some had obtained graduate schooling by 1950 and 1960.

[11]This kind of reasoning has been applied, for example, by Solmon, The Definition and Impact of College Quality, NBER Working Paper #7, pp. 28-29. Chiswick (1972, pp. 3-15) applies a similar procedure.

The availability of cost data allows a direct estimate of r. In column 2 of Table 2, the results of regressing earnings on $\sum_{j=1}^{S} K_{ij}$ are presented. The estimated rate of return of 6.5 per cent, is surprisingly close to the estimate derived from equation (1) with the assumption that $K = 1$. This occurs because of two offsetting biases. The coefficient on years of schooling in equation (1) is biased downward because no account is taken of the fact that $K < 1$, while ignoring the positive correlation between K and S imparts an upward bias to the coefficient. Note also that the estimated rate of return on graduate schooling also rises in magnitude and significance, since those who invested more in their undergraduate schooling were more likely to obtain graduate schooling. Without accounting for the greater K of these people the rate of return to college was biased upward, and consequently, the rate of return to graduate schooling was biased downward.

Since a B.A. is a prerequisite to most graduate programs, this suggests that more intensive undergraduate work may provide its return by allowing entrance to a graduate program. The coefficients in Regression #2 should not be taken to mean that the rate of return to graduate school is twice as great as the rate of return to undergraduate schooling, for reasoning as we did above, the coefficient on years of graduate school cannot be interpreted as a rate of return. And, if the intensity and years of graduate schooling are positively correlated, the coefficient of equation (2) is an overestimate of the rate of return.

Since data are available, it seems worthwhile to determine the relationship between earnings and the various components of average K--tuition, fellowships, foregone earnings, etc.

Since: $r \sum_{j=1}^{S} K_{ij} = rS + r\left[\frac{T_i - F_i - A_i - E_i}{O_i/S}\right]$

T_i = total tuition for i^{th} individual

F_i = total scholarship for i^{th} individual

A_i = total assistantship for i^{th} individual

E_i = total earnings for i^{th} individual

O_i = total opportunity cost

S_i = years of schooling

We can also allow different contributions from different components of K,[12] as in Regression #3.

The hypotheses about the signs of these variables depend on their effects on the amount of human capital acquired per school year. Because it is assumed that greater yearly tuition will correspond to greater school inputs per academic year, the partial effect of tuition is expected to be positive.[13] The per cent of opportunity cost covered by earnings is a proxy for the amount of time allocated to non-academic uses per school year. Thus undergraduate earnings should be negatively related to human capital acquired, and thus to future income. However, undergraduate earnings may be a measure of market ability, and therefore positively related to future earnings. Assistantships usually require working in the university, and therefore allocating time away from studies, and are expected to be negatively related to future earnings. However, since the most able students are the recipients of assistantships, the coefficient in the regression may be biased toward zero.

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[12]This approach has also been taken by Wachtel (1973, p. 5a).

[13]If tuition is related positively to parental wealth, and not at all to the quantity of school inputs purchased, its expected sign would still be positive. In this context, the two hypotheses cannot be differentiated.

Scholarships holders, like recipients of assistantships, should be an exceptionally able group. However, since scholarships do not usually require taking a university job, their net effect on later earnings should be positive.

In column 3 of Table 2 we see that although all the components of schooling intensity have the expected signs only years and tuition intensity have significant effects on later earnings. Although scholarship holders had higher earnings than assistantship holders, or those with jobs, these differences are not significant. We can infer, at least for the very able, that a little hard work never hurt anybody (in terms of future earnings) Column 4 presents the significant variables only, and indicates that the increase in earnings from an additional year of schooling at the average tuition intensity (.15) is about 3.7 per cent. Further, there is evidence here for decreasing marginal productivity of schooling within a given year, because increasing school years by 1/10 of a year, while maintaining total tuition expenditures will increase annual earnings by 0.3 per cent, while increasing tuition expenditures by the opportunity cost of 1/10 of a year of schooling, while keeping school years constant will add only 0.2 per cent to annual earnings.

Table 2

Annual Earnings as a Function of Human Capital Investments. Dependent Variables is Log of Earnings in 1947 Dollars

	(1)	(2)	(3)	(4)
C	3.39 (30.7)	3.41 (31.6)	3.36 (30.7)	3.36 (30.7)
College Years	.069 (5.30)		.034 (1.91)	.033 (2.09)
Graduate Years	.047 (1.59)	.094 (3.25)	.076 (2.17)	.060 (2.05)
Total Cost*		.065 (5.60)		
Experience	.049 (4.29)	.051 (4.47)	.051 (4.55)	.051 (4.57)
Experience^2	-.0005 (-1.80)	-.0005 (-1.98)	-.0005 (-1.99)	-.0006 (-2.01)
$S \times k_{\text{Tuition}}$			.023 (3.81)	.024 (4.05)
$S \times k_{\text{Scholarship}}$			3.41 (.20)	
$S \times k_{\text{Assistantship}}$			-19.1 (-.88)	
$S \times k_{\text{Earnings}}$			-.375 (-.11)	
R^2	.148	.151	.164	.163
N	901	901	901	901

$$\text{*Total Cost} = \sum_{j=1}^{S} K_{ij}$$

III. Ability, Intensity and Earnings

Ability is a major factor shifting the marginal productivity and marginal cost curves for intensity and years of schooling. To see how high ability affects the market rental on equivalent years of schooling, earnings of the high ability males from the Terman sample are compared with earnings of males reported in the U.S. Census in this section.

Ratios of mean income earned by Terman sample members and by males reporting income in the 1940, 1950, and 1960 Census are reported in Table 3. The data for the Terman sample were collected from questionnaires administered in 1940, 1950, and 1960 and the data for the three years are defined as follows:

1940: Monthly wage and salary income, times 12, for sample members who were employed full time;

1950: Annual employment income in 1949 for sample members employed full time;

1960: Annual employment income in 1959 for sample members employed full time.

The income data are presented in Appendix Table A, along with Census data for comparison. Ratios of the incomes of Terman subjects to incomes of Census respondents are presented in Table 3.

In all Census years for all education and age groups, average incomes of the Terman sample exceeded the mean incomes of the population at large. Where comparisons are possible of similar age-education groups in 1940, 1950, and 1960, no marked trends are discernible. That is, the ratio by which Terman incomes exceed Census incomes for individuals of a given age and education does not rise or fall in a systematic way between 1940 and 1960.

Table 3

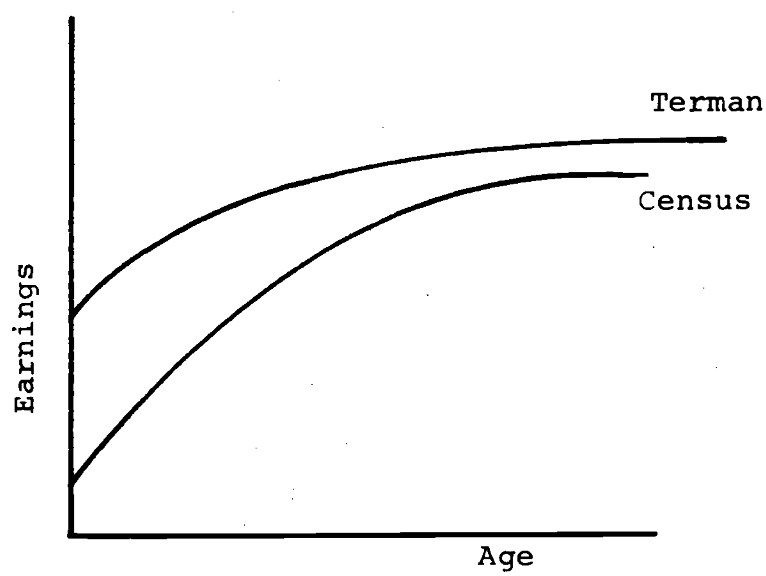
Ratio of Mean Incomes of Terman Sample to Census by Age and Education: 1940, 1950, 1960

Age	Education								
	High School 4 Years			College 1-3 Years			College 4 Years		
	1940	1950	1960	1940	1950	1960	1940	1950	1960
I. Age Adjusted									
22-24	3.7			3.6			3.8		
30-34	3.0			2.8			2.3	1.5	
30-34	2.3	1.8		1.9	2.7		1.9	1.6	
35-44	2.2	2.7	1.1	1.4	2.0	1.8	1.6	1.7	1.4
45-54		1.7	1.9		1.2	1.6		1.6	1.2
55-64			1.1			1.1			1.2
II. Experience Adjusted									
Age of Terman Sample									
20-22									
23-27	3.3			2.7			2.4		
28-32	2.4			2.2	1.2		1.8	1.3	
33-42	2.0	2.0		1.9	2.1	1.3	1.4	1.7	1.2
43-52		3.5	1.7		1.6	1.9		1.6	1.3
53-62			2.4			1.5			1.2

Source: Appendix Table A.

However, if a given cohort is followed through the three Census years, the percentage by which their income exceeds Census income shows a pronounced downward trend. (There are decreases in 16 or 18 cases.) The null hypothesis that there is no trend in the ratios (i.e., the probability of decrease = .5) can be rejected at the .001 level of significance. Unusually high ratios in 1940 may be due to a sampling bias in the 1940 Census, since earnings were reported only for persons with no more than $50 of other income. Because of this restriction many persons with high earnings may have been excluded, leading to a downward bias in the earnings data reported by the Census. However, since the comparisons in 1940 cover primarily the early years of the life-cycle, the Census sample may not be overly biased. Earnings of the Terman sample may also have been overestimated due to the assumption that sample members worked a full year. However, the trend in income ratios over time is not solely an artifact created by data deficiencies, since the ratios of Terman to Census incomes also falls between 1950 and 1960. Furthermore, there is a decrease in the ratio with age within education groups in a given year in 18 of 22 cases. (The probability of obtaining this result when p = .5 is .002.)

Figure 4 illustrates the situation. Terman sample members begin their earnings life with greater initial stocks of human capital, and while their earnings are always greater than mean earnings from the Census, they rise at a less rapid rate.



Lifetime Earnings of Terman and Census Sample of Same School and Age Cohort

Figure 4

The finding that both over time and within a given year, relative earnings of high ability males fall with age is surprising and contrasts with the findings for relative earnings over the life cycle for persons who differ in the amounts they possess of another kind of human capital--years of schooling. Mincer finds (1973, p. 70) that relative wages of the more schooled increase with age, although experience-income profiles are nearly parallel for log of weekly earnings and tend to converge for log of annual earnings. Using equation (2) to compare earnings of groups m and n with different initial endowments of ability, E_o, but the same number of years of schooling, we can write:

$$\ln\left(\frac{E_{mj}}{E_{nj}}\right) = (\ln E_{om} - \ln E_{on}) \qquad (5)$$

$$+ r_s \sum_{t=0}^{S} (K_{tm} - K_{tn}) + r_t \sum_{t=S+1}^{J-1} (K_{tm} - \delta_{tm}) - (K_{tn} - \delta_{tn})$$

$$+ \ln(1 - K_{jm}) - \ln(1 - K_{jn}).$$

Schooling investments, which occur until time S, have been separated from post-school investments. Net post-school investments (over depreciation) earn a return of r_t, while the return on schooling investments is r_s.

Since the difference between the initial endowments the schooling investments of the two groups remain constant over time, the only source of variation in their relative incomes over the life cycle is in the term, $(K_t - \delta_t)$ reflecting post-school investments and depreciation.

In this model post-school investments are financed by lower net (observed) earnings. Thus the less steeply rising earnings profile of the Terman group implies that vis à vis the Census group either their post-school investments are a smaller proportion of gross potential earnings (although the value of these investments may be greater than those of the Census group) or that the depreciation on their human capital is greater.

Mincer concludes (1973, Chapter 2) that persons with more human capital in the form of years of schooling, also have greater money expenditures for post-school investments. But he finds a zero or negative correlation between time spent in schooling and in post-school investments. The Census and Terman earnings profiles converge even more rapidly than those of various schooling groups. There are three possible explanations of this convergence:

1. Percentage of gross earnings invested in post-school investment is lower for the Terman group. It must be recalled that the Terman group, which was selected because of its high I.Q. scores is being compared with a group with equivalent years of schooling. The one thing I.Q. scores predict best is ability to succeed (i.e., acquire human capital) in school. Thus the "ability" criterion may be defined in such a way is to have a nonneutral effect on productivity in producing human capital in school and on the job. High I.Q. persons may invest more intensively during school years, because they are relatively efficient at acquiring capital through schooling, while others invest more intensively on-the-job.

2. A more rapid rate of depreciation among the very able is another possible source of their slower rate of increase in net earnings.[14] The pattern of decline of human capital for various levels of ability is not immediately known. However, not all the differential in earnings between average and high ability people is attributable to ability.

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[14]Mincer and Polachek find that more educated females' human capital depreciates at a higher rate when the woman is out of the labor force.

The Terman sample members, had family characteristics which are known to be associated with higher earnings. For example, they had parents with nearly four more years of schooling than the average of their cohort and higher family income. These background variables may affect initial earnings to a greater extent than later earnings. In the Terman sample (Leibowitz, 1974) the positive impact of family income on earnings decreases over time. Thus the shrinking differential between high and average ability persons may be due to the falling value of family contacts.

3. Although men with the same numbers of years of schooling and continuous labor force experience should have the same number of years of labor force experience, this may not be the case in this sample. Because Terman sample members showed high I.Q.'s while still in grade school, many were accelerated in their schooling. Nearly half (49.3%) of the sample graduated from high school before age 17 and the mean age at college graduation was 21.5,[15] whereas the mean age for all college graduates was calculated as 24 by Hanoch.

Because of the greater intensity of their early schooling, Terman sample members have approximately two more years of market experience for any given schooling level. This would mean that the earnings function of Terman subjects diagrammed in Figure 4 should be shifted to the left to compare with persons of equivalent experience from the Census. When incomes are again computed, we see that the ratios decline less steeply over time and with age. (See Panel 2, Table 3.) (Unfortunately, the shift caused some of the cells to have too few observations

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[15]Terman, Vol. IV, pp. 264-69. This was also the modal and median value (my calculation).

to be reliable.) Using "experience adjusted" comparisons, the proportion of declines from one Census year to the next remains significantly different from .5 at the one per cent level, but the fraction of declines within age groups is only significantly different from one half at the 22 per cent level.

Before correcting for their accelerated schooling, the high ability sample earned from 10 per cent to 280 per cent more than persons with average ability and the same age and schooling. Much of the difference on lifetime earning patterns disappears when the data are adjusted to account for the greater intensity of early schooling of the high ability sample. The much greater earnings of high ability males shown in this sample for given schooling levels contrasts with rather modest effect of ability on earnings found by Griliches, Hause, and Taubman. Given the very high I.Q. level in the Terman sample, this may imply a strongly nonlinear effect of ability on earnings.[16]

Some of the differential between earnings of the high ability sample and those of average ability may be due to correlation of ability, with other factors such as higher quality of schooling or higher family incomes. It is not possible to test these alternatives given the lack of a detailed longitudinal data for persons of average ability comparable to the Terman study.

However, one of the causes of differences in the rates of change of income does appear to be related to different ages of labor force entry in the two samples, caused by accelerated schooling of the more able. Whereas comparisons of earnings among individuals with differing amounts of schooling should properly be adjusted for years of market experience,[17] comparisons among individuals differing in ability should not. One of the major routes for collecting the return to high ability would appear to be early entry to the labor force, since earnings in the early years of the life cycle have a substantial weight in the calculation

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[16]This implication was suggested to me by Gary Becker.

[17]See J. Mincer's development of the problem in Schooling, Experience and Earnings.

of present value of income streams.

IV. Summary

The purpose of the present paper has been to argue that years spent in school do not adequately characterize the inputs or the outputs of the process of investing in human capital. In particular, we have demonstrated that the rate of return on schooling investments cannot be identified from the linear regression of log incomes on years of schooling, even given the knowledge of the average ratio of expenditures to full-time earnings. Empirically, we have shown that this ratio, K, is positively related to years of schooling, and that consequently rates of return which do not account for this correlation are biased upward. Lastly we have shown that greater intensity of schooling investments may allow high ability students to enter the labor force earlier than their peers of average ability, and that the consequent increase in discounted value of lifetime earnings may be a major way of collecting the returns to high ability.

Appendix A

Mean Incomes of Terman Sample and Census by Age and Education: 1940, 1950, 1960

Age	Education: High School 4 Years			College 1-3 Years			College 4 Years		
	1940	1950	1960	1940	1950	1960	1940	1950	1960
Terman Sample[1]									
22-24	3192			3380			3889		
25-29	3655			3973			3736	4833	
30-34	3629	6200		3495	10528		4306	7689	
35-44	4278	10535	7500	3277	9259	14708	4981	10193	15520
45-54		7375	12869		5925	13954		10808	16572
55-64			7800			9368			16462
65+									
Census									
22-24	869[2]	[3]		936[2]		[3]	1036[2]	[3]	
25-29	1210			1400			1645		
30-34	1559	3488	5594	1804	3923	6059	2299	4695	7196
35-44	1987	3888	6606	2269	4602	8127	3160	6039	11118
45-54		4296	6875		4944	8801		6578	13804
55-64		4108	7004		4500	8829		6188	13638
65+									

Sources: See attached.

Sources:

1. Calculated from the Terman sample.
2. U.S. Bureau of the Census (1940), Table 33, p. 177.

   Data cover 1939 wage and salary income for native white males with income and nonwage income less than $50. No restriction on region.
3. U.S. Bureau of the Census (1950), Table 12, pp. 53-108.

   Data cover 1949 wage and salary income for males with income in North and West regions.
4. U.S. Bureau of the Census (1960), pp. 196-7.

   Data cover 1959 earnings of white males with earnings in experienced civilian labor force. No restriction on region.

Note:

An equal distribution within income categories was assumed in calculating means.

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