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ABSTRACT

The report describes a study designed to examine substitution between formal schooling and dropouts' post-school training or experience in the labor market. The basic hypothesis is that if formal schooling and post-school training are substitutes, then experience-earnings profiles measured in the logarithm of earnings should tend to converge. To test the hypothesis, a sample of approximately 11,000 males over 14 years, who had nonfarm earnings in 1966, and who were not in school or in the military, was selected from the Survey of Economic Opportunity conducted in 1967 by the Census Bureau. The sample was divided occupationally into eight subsamples (professional/technical; manager, official, proprietor; clerical; sales; skilled crafts; operatives; service workers; and laborers) on which linear regressions were run to determine the extent to which the post-school training of dropouts successfully substituted for the additional formal education received by high school graduates. The linear regressions revealed a very strong tendency for almost complete substitution to occur in all but two of the occupational groups (manager, official, proprietor; and skilled crafts). These tentative results lead to the conclusion that dropping out may be rational from the point of view of both the individual and society. (Author/JR)

FINAL REPORT

PROJECT NO. 2-0633
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LABOR MARKET SUBSTITUTION BETWEEN SCHOOLING AND ON-THE-JOB TRAINING

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I. Introduction

It is the purpose of this study to examine the possibility of substitution between two of the principal forms of human capital investment: formal schooling and post-school training.[1] Determination of the existence of such substitution is basic to our understanding of the training process, since currently we have very little knowledge of the relationship between these two basic forms of human capital. In particular, we cannot say whether, at present, formal schooling is a unique stage in the investment process, generating skills not otherwise obtainable, or if it is largely a means of accelerating the acquisition of skills which might otherwise be obtained during the course of employment. Indeed, examples of parallel school and non-school training are easily found. At the professional and technical level, a form of apprenticeship persisted well into this century in law and engineering which allowed many to formally enter the profession without obtaining a professional degree. Computer personnel at all levels currently are being trained both in school or on the job. At the blue-collar level, many school systems offer programs which are explicitly recognized as some degree of substitute for apprenticeship.

As indicative as these examples are, however, they are only isolated illustrations of the principle underlying this study. They do not represent a basis for arguing generally that substitution is an important phenomenon. It is quite possible, for example, that school-trained and job-trained computer programmers represent entirely different packages of skill to their employers, and as such, face entirely different earnings prospects upon completion of their respective programs.

In order to ascertain the importance of substitution as a general phenomenon, it is necessary to establish a mode of analysis which is itself general in its scope; that is, an analysis which systematically treats the labor force as a whole. As will quickly become apparent, the adoption of such a mode involves a high degree of simplification and abstraction. The richness of detail which might be expected from an elaborate case by case study of the sort suggested by the examples above is necessarily absent. But in return, we are able to conclude from the evidence developed by this study that substitution between schooling and post-school training is clearly a phenomenon of some importance in the labor market.

The sections which follow will treat in turn the theoretical structure underlying the analysis, the empirical analysis which was undertaken and a concluding summary.

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[1] I have deliberately avoided the use of the term "on-the-job" training, since it tends to connote organized programs conducted by employers. This study is directed at the acquisition of all forms of earnings-enhancing skill, including what is usually called "experience".

2. Theoretical Analysis

A. The Basic Structure

Economic analysis of training traditionally has focussed on the impact of training on earnings. In particular, training is viewed as an investment process which increases the productive capacities of the individual and consequently the wage which his labor services can command in the labor market.

The analysis which follows here continues in that tradition. Broadly stated, it infers from the pattern of earnings, which is presumed to be the result of some pattern of investments, an important characteristic of the investment process. In this case, the investment phenomenon to be inferred is that of substitution between schooling and post school training.

A simple example will serve to illustrate both the inferential process and what is meant by substitution.

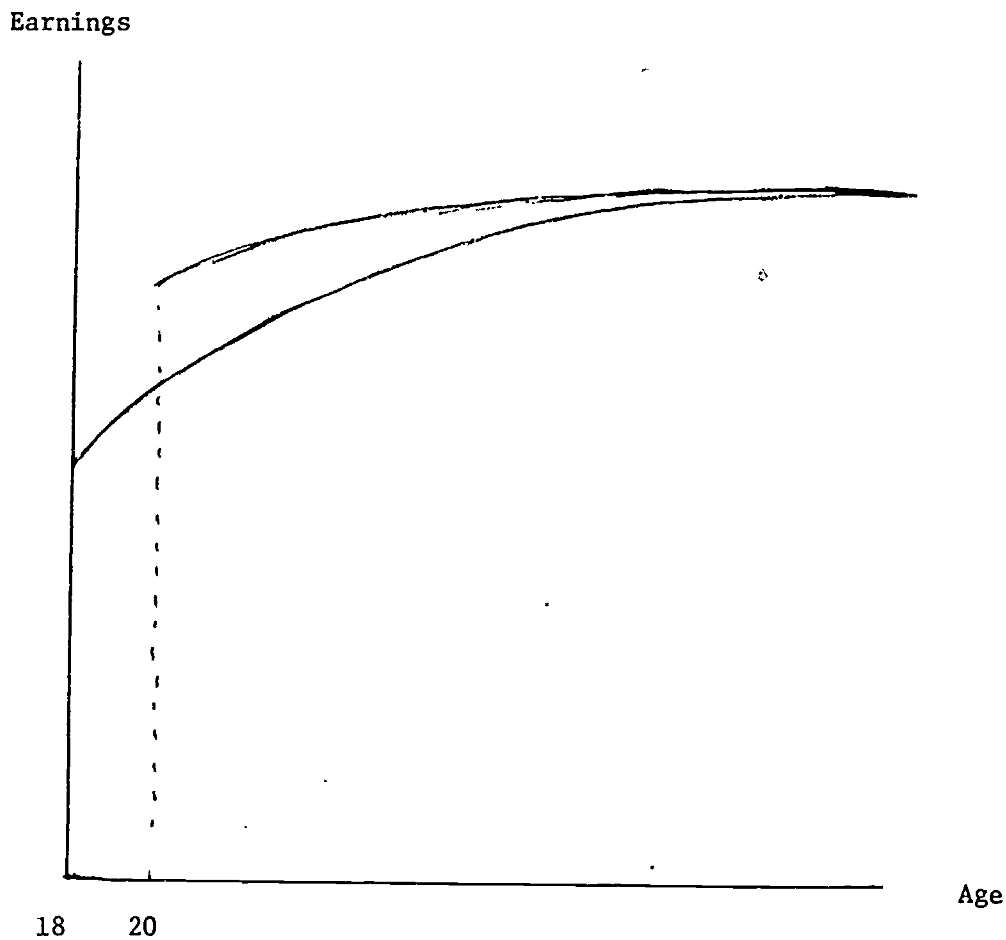
Suppose that within an occupation, one observed that workers tended to have two distinct educational backgrounds--for example, two years and four years of high school. Suppose further that detailed work histories revealed higher entry level jobs at substantially higher pay for graduates than for drop-outs--high enough, in fact, to exceed the pay of drop-outs with two years work experience. Assume as well that drop-outs receive training on the job not provided to graduates, and finally, that the earnings of drop-outs and graduates became equal sometime after age thirty and remained so thereafter. This situation is readily summarized diagrammatically by Figure 1, which depicts the age-earnings profiles of the two groups of workers.

In terms of this study, these data, if observed, would be described as a case of complete substitution between schooling and post-school training. At the point in their working lives at which occupational training has been completed, the average stock of human capital accumulated by each group is valued identically in the labor market. In other words, the two different training programs lead eventually to the same end product.

To say that there is complete substitution between schooling and post-school training, is not to say, however, that additional schooling is therefore of no economic value. In reviewing this example, one might be tempted to conclude that the two additional years of formal education obtained by the high school graduates represent no net gain, either to the graduates or to the total stock of human capital available to the economy. The drop-outs, after all, do eventually obtain as much training as the graduates. This, however, is not the sense in which substitution is meant in this analysis, nor indeed is the conclusion itself correct. The graduates do obtain a return to their schooling in the form of higher earnings during the years in which the drop-outs are obtaining their training on the job. Further, the average level of the human capital stock is raised by the simple fact that the human capital obtained by the graduates is present for a larger fraction of their working lives.

ILLUSTRATION OF EARNINGS CONVERGENCE

Figure 1



This simple example does lead to one important conclusion: if schooling to a substantial degree serves as a substitute for later post-school training, then a significant proportion of the growth of the human capital stock in the U.S. may have resulted simply from the acceleration of skill acquisition.

In discussing the example above, we examined a polar case--that of complete substitution. It is also possible in the same context to examine the consequences of a complete lack of substitution. Suppose that instead of the process of "catch-up" hypothesized earlier, we found that the pattern of time spent in post-school training was identical for both drop-outs and graduates. As a result, the proportion of earning capacity expended on training after completion of school would effectively be the same for each group. Obviously in this case, there will be no catching-up on the part of drop-outs. Furthermore, the additional years of schooling cannot be said to be in anyway a substitute for post-school training, since the entire period of school attendance is a net addition to the graduate's life-time accumulation of human capital.

A priori, there seems to be no particular grounds for expecting one or the other of the two extremes I have described to predominate in the labor market. Indeed, some intermediate position seems likely. In any event, to actually make the kind of test described above requires data which are simply not available. Nowhere, to my knowledge are there accurate data available on time spent at post-school training. But we do have substantial quantities of data available depicting what people earn at different ages and with differing amounts of schooling. The question is, can we infer anything from these data? In fact, it is possible, but first it is necessary to derive a working model which allows us to do it.

B. The Time Equivalents Model of Investment in Training [2]

The basis for a model which will allow an appropriate analysis of substitution lies in a formulation of the human capital model developed initially by Becker and Chiswick and later extended by Jacob Mincer.[3] They begin with a basic human capital equation for the individual, originally described by Becker,[4] of the form

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[2] This subsection and subsection c closely parallel similar discussion in my Ph.D. dissertation. ("Investment in Training and the U.S. Occupational Structure of Earnings, Columbia University, 1971).

[3] Gary S. Becker and Barry Chiswick, "Education and the Distribution of Earnings," American Economic Review, LVI (May, 1966), pp. 358-69. The somewhat modified version of their basic formulation used here and its extension are found in Jacob Mincer, "The Distribution of Labor Incomes: A Survey," Journal of Economic Literature, VIII (March, 1970), p. 12.

[4] Gary S. Becker, Human Capital (New York: Columbia University Press, 1964).

$$Y_j = X_j + \sum_{i=0}^{j-1} r_i C_i + (-C_j), \tag{1}$$

where Y_j = net earnings in the current year,

X_j = that part of current earnings due to the individual's basic endowment,

C_i = costs of all investments made in the past, from year 0 to last year,

C_j = costs of any investments made in the current year,

and r_i = rates of return on past investments.

That is, current net earnings consist of the earnings attributable to the individual's "original endowment" of productive capability, plus the returns on all previous investments, minus the costs of any current investment. Note that if the costs of current investments are incurred solely through reduced earnings, net earnings will equal observed earnings. This form of the equation, while theoretically powerful, is limited in its empirical usefulness because it is specified in terms of dollar outlays for human capital investments. As already noted, such data are only sketchily available. The objective of Becker and Chiswick was to derive a version of the model more applicable to data which are available.

Thus, in equation (1), set the quantity $X_j + \sum_{i=0}^{j-1} r_i C_i = E_j$,

which can be called gross earnings in the current period. Further, define $k_i = C_i/E_i$; that is, k_j equals the fraction of any period's gross earnings which is invested. Thus, $C_i = k_i E_i$. Current gross earnings are equal to the previous period's gross earnings plus the return on any investment in the previous period; that is,

$$\begin{aligned} E_j &= E_{j-1} + rC_{j-1} \\ &= E_{j-1} + r_{j-1}k_{j-1}E_{j-1} \\ &= E_{j-1}(1 + r_{j-1}k_{j-1}). \end{aligned} \tag{2}$$

But, in turn, $E_{j-1} = E_{j-2}(1 + r_{j-2}k_{j-2})$,

$E_{j-2} = E_{j-3}(1 + r_{j-3}k_{j-3})$, etc.,

until, $E_{j-j} = E_0$.

Thus, by substitution of the recursive terms above,

$$\begin{aligned} E_j &= E_0(1 + r_0k_0)(1 + r_1k_1)\ldots(1 + r_{j-1}k_{j-1}) \\ &= E_0 \sum_{i=0}^{j-1} (1 + r_ik_i). \end{aligned} \tag{3}$$

Converting the equations to natural logarithms,

$$\lg E_j = \lg E_0 + \sum_{i=0}^{j-1} \lg(1 + r_i k_i). \quad (4)$$

Furthermore, since net earnings, $Y_j = E_j - C_j = E_j(1 - k_j)$,

$$\begin{aligned} \lg Y_j &= \lg E_j + \lg(1 - k_j) \\ &= \lg E_0 + \sum_{i=0}^{j-1} \lg(1 + r_i k_i) + \lg(1 - k_j). \end{aligned} \quad (5)$$

As we observed above, if all investment costs in period j are in the form of foregone earnings, then Y_j equals observed earnings. This is equivalent to saying that K_j represents the fraction of the current year spent investing. Thus, if we can assume that in each year all costs are incurred through foregone earnings, the model becomes one in which investment is measured strictly in time units. In terms of this study, this is obviously a crucial step, since the substitution process described in the hypothetical example above consists of reducing time spent on post-school training by spending more time in school.

We are, of course, assuming that all training costs are being incurred in the form of foregone earnings. In the case of on-the-job training, this is a reasonably sound assumption, since reduced earnings are the most likely form of payment. For the employer, this form of payment eliminates difficulties and costs which might arise from explicit charges for training; for the employee, it eliminates the possibility of paying income taxes on all or part of the income rebated to the employer.[5]

In the case of schooling, the simplest assumption is that $k_j = 1$; i.e., that one year of schooling costs a full year's earnings. While at first glance implausible, in fact this is a fairly solid assumption. Most primary and secondary students have few, if any, costs beyond the cost of their own time, and their annual earnings are negligible. College and graduate students do have substantial direct tuition costs, but they also tend to have part-time and summer earnings of roughly equal magnitude. Becker estimates that cash outlays account for 26 percent of the cost of a year of college, while the annual earnings of college students average approximately one-half of potential full time earnings.[6] Thus, the full cost of a college year is, on the average, almost precisely one year's gross earnings--i.e., E_j.

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[5] For further discussion of this point, see Jacob Mincer, "On-the Job Training: Costs, Returns and Some Implications," Journal of Political Economy, LXX:5, Part 2 (Supplement, October, 1962), pp. 50-79.

[6] Becker, Human Capital, p. 75 and pp. 169-71.

As a consequence of these assumptions, it is possible to rewrite the earnings function in still a more useful form. First of all, since by assumption $k_i = 1$ and other evidence indicates that r_i is likely to be in the range of .10 to .20,[7] the term $\sum_{i=0}^{j-1} lg(1 + r_i k_i)$ may be closeiy approximated by $\sum_{i=0}^{j-1} r_i k_i$. Secondly, since for all years in school it was assumed that k = 1, that portion of the investment in training which is represented by school can be written $\sum_{i=0}^{s} r_i = r_s S$, where r_s equals the average rate of return to schooling. Hence, we may now write the earnings function of the individual as

$$LgY_j = lgE_0 + r_s S + \sum_{i=s+1}^{j-1} r_i k_i + lg(1 - k_j), \qquad (6)$$

where Y_j is now equal to the observed annual earnings of a full time worker.

The functional form above would be directly applicable to available data on either the individual or occupational level if we had values for the term representing the fractions of years beyond school devoted to training. To my knowledge, such data do not exist. Nevertheless, Mincer has shown that it is possible to include the average effects of post-school training by combining theoretical predictions about the time path of such investment with some simple assumptions about the precise shape of that time path.[8]

A basic prediction of human capital theory is that the quantity of human capital produced per period by the individual will tend to decline continuously after reaching a peak early in life. As shown in separate papers by Becker and Yoram Ben-Porath,[9] the individual can

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[7] Ibid., pp. 69-78 and pp. 127-31. Also, Ciora Hanoch, "An Economic Analysis of Earnings and Schooling," Journal of Human Resources, Vol. II (Summer, 1967), pp. 310-29.

[8] Mincer, "The Distribution of Labor Incomes," pp. 16-7. See also Jacob Mincer, "Schooling, Age and Earnings," in Human Capital and Personal Income Distribution (New York: National Bureau for Economic Research, in progress).

[9] Gary S. Becker, "Human Capital and the Distribution of income," W. S. Woytinsky Lecture No. 1 (University of Michigan, 1967); Yoram Ben-Porath, "The Production of Human Capital and the Life Cycle of Earnings," Journal of Political Economy, LXXV (August, 1967), pp. 352-65.

be viewed as producing human capital by combining his own time and purchased inputs to produce capital according to some production function of the neo-classical type. The individual's time represents his productive capacity and consists of the sum of the service flows from his original endowment and any capital previously produced. These service flows are available to the individual in limited quantity and their use in the production of human capital means, of course, that they cannot be used to produce current disposable income. The combination of a limit on one of the product inputs and the deferral of income means that the marginal cost of an addition to capital in any one time period is rising. Regardless of the shape or level of the marginal revenue curve, there will be a limit on the quantity produced in that period. As Ben-Porath points out, in early periods (say, during schooling) the amount of human capital produced per period probably rises over time; as the individual's stock of capital increases, so does the quantity of personal productive capacity available for further capital production.[10] However, this expansion must come to an end, for the marginal revenue curve must continually shift downward as time passes. The return on the investment in any period consists of the present discounted value of the addition to future income; but life is finite, and the number of future periods over which the gain may be realized steadily diminishes. This means that at some point the equilibrium level of investment will begin to decline and will do so monotonically.

The predicted pattern of investments over the life cycle can be represented by the curve labeled "$ invested" in Figure II. Included in the diagram is the time shape of k_i implied by the pattern of dollar investments. In principle, k_i could actually exceed one, since the sum of foregone earnings and cash outlays for tuition, etc., could exceed potential full time earnings. However, we have assumed that this does not occur. Thus, the time path of k_i is horizontal at a value of one until the individual leaves school, from which point on it must steadily decline.[11]

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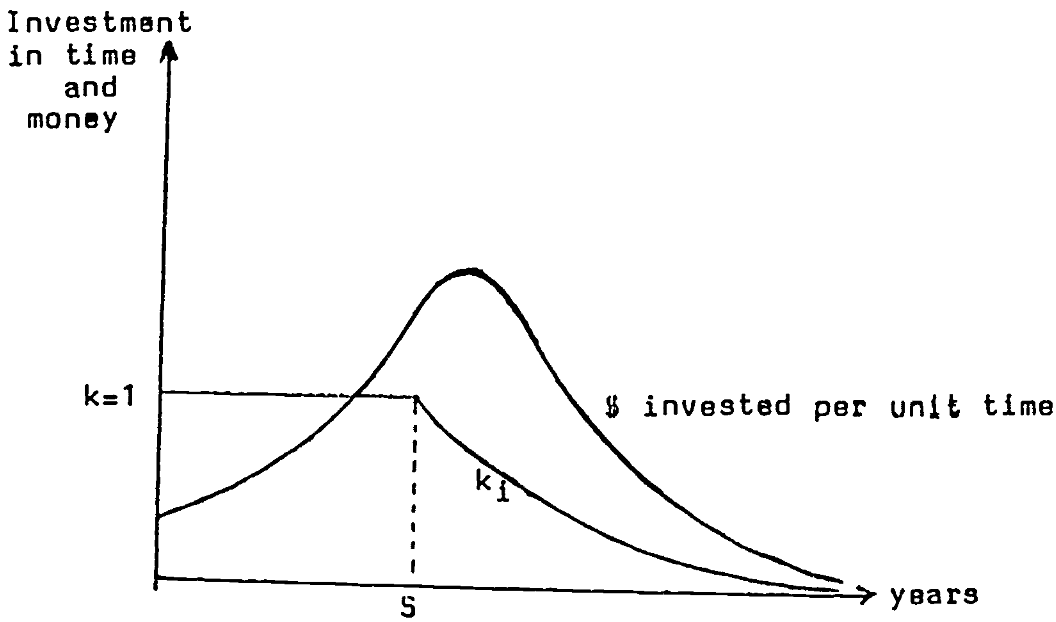
[10]This can be invisioned diagrammatically as a rightward shift in the point at which the marginal cost curve becomes perfectly inelastic. The basic marginal cost curve shifts only slightly, if at all, because productivity in human capital production and the opportunity cost of the individual's time in production (wages) are assumed to increase in proportion.

[11]One aspect of earnings and investment which has not been discussed is the question of depreciation. Depreciation and the obsolescence of skills can be expected to cause a decline in earnings late in life. The explicit consideration of depreciation in the type of function specified above is virtually impossible, since the only way in which it can be introduced is as some additional function of time. Hence, in the analysis which follows, investment will simply be considered to be net of depreciation. This device is conceptually straightforward and implies that in later years the investment represented by k(t), as in Figure 2, may become negative, causing a decline in earnings late in life.

Figure 2

PROFILES OF MONEY AND TIME INVESTED



Note

The curve labeled "$ invested" is shown to increase at an increasing rate during school years, since reinvestment of the whole stock of capital implies compound growth. The rate of increase of $ invested begins to fall when k=1 until the peak of $ is reached. This peak can occur very soon after schooling is completed if k_i diminishes very rapidly.

It is the theoretically necessary continuous decline in k_i which Mincer exploits to derive a meaningful post-school investment term in equation (6). If we assume that the k_i are some function of time for each individual, and that the r_i are all equal, equation (6) can be rewritten as

$$\lg Y_j = \lg E_0 + r_s S + r_j \sum_{t=0}^{j-1} k(t) + \lg [1 - k(j)], \quad (7)$$

where t now signifies post-school years. By assuming that the post-school investment process is fully continuous, one can simplify the equation still further:

$$\lg Y_j = \lg E_0 + r_s S + r_j \int_0^j k(t)dt + \lg[1 - k(j)]. \quad (8)$$

The only step which remains is the specification of a functional form for k(t), since direct measurement of post-school investment time is not possible with available data.[12] Nevertheless, time (or time equivalents invested by the individual beyond school will be some monotonically decreasing function of work experience. Thus, on average, differences in years of labor force experience should represent differences in current and completed post-school investments, which in turn yield differences in earnings. And labor force experience is a variable for which we do have data.

The exact nature of the relationship between earnings and experience clearly depends on the nature of the relationship between investment and experience. In applying this model to the individual distribution of earnings, Mincer employed two basic formulations of time invested as a function of experience: (1) $k(t) = k_0 - bt$, where the fraction of time invested is a decreasing linear function of time spent in the labor force; and, (2) $k(t) = k_0 e^{-\rho t}$, where the fraction invested diminishes exponentially with labor force experience.[13] In each case, k_0 represents some initial level of investment.

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[12] One attempt to obtain direct measures is represented by the work of Scoville, who calculated schooling and post-school training requirements for 204 Census occupations based on indices of skill requirements established by the U.S. Department of Labor for some 4,000 occupational titles. These "requirements," however, do not measure the actual skill levels of workers currently in the occupations, which is the variable sought here. J. G. Scoville, "Education and Training Requirements for Occupations," Review of Economics and Statistics, XLVII (November, 1966), pp. 387-94.

[13] Mincer, "The Distribution of Labor Incomes;" and, "Schooling, Age and Earnings."

Each of these functional forms implies a somewhat different experience-earnings profile when introduced into equation (8). Thus, in the case of the linear function (abstracting from differences in schooling temporarily),

$$\lg Y_j = \lg E_0 + r_t \int_0^j k(t)dt + \lg[1 - k(j)]$$

$$= \lg E_0 + r_t \int_0^j (K_0 - bt)dt + \lg[1 - (k_0 - b_j)] \quad (9)$$

$$= \lg E_0 + r_t[k_0 j - 1/2\ bj^2] + \lg[1 - (k_0 - b_j)].$$

Applying a Taylor series expansion to the final term yields

$$\lg[1 - (k_0 - bj)] = -[k_0 - b_j + 1/2(k_0 - bj)^2 + 1/3(k_0 - b_j)^3 \ldots]$$

$$= -[k_0 - bj + 1/2k_0^2 - k_0 bj + 1/2b^2 j^2].^{14} \quad (10)$$

Thus, the final form of the earnings function becomes:

$$\lg Y_j = [\lg E_0 - k_0 - 1/2k_0^2] + [r_t k_0 + b + k_0 b]j - 1/2[r_t b + b^2]j^2. \quad (11)$$

That is, the implied form of the post-school earnings profile is approximately a parabola.

Similar manipulation of the function $k(t) = k_0 e^{-\beta t}$ yields

$$\lg Y_j = \lg E_0 + r_t \int_0^j k_0 e^{-\beta t} + \lg[1 - k_0 e^{-\beta j}]$$

$$= \lg E_0 + r_t k_0/\beta - (r_t k_0/\beta)e^{-\beta j} - k_0 e^{-\beta j} - 1/2k_0^2 e^{-2\beta j} + \ldots$$

$$\lg Y_j = \lg E_0 + r_t k_0/\beta - k_0(1 + r_t/\beta)e^{-\beta j} - 1/2k_0^2 e^{-2\beta j}. \quad (12)$$

The implied form here is approximately a Gompertz curve.

The next step is to see if these implied experience-earnings profiles correspond to profiles actually observed. Mincer tested the human capital model using these two profiles with regressions on the annual earnings of approximately 30,000 white, non-farm male workers from the 1960 U.S. Census. The results were as follows:

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[14]Truncation beyond the second power is necessary to avoid problems of interpretation. The presence of a third-power term in the earnings function could as easily imply a quadratic form of k(t). The approximation will be quite close so long as k_0 is not close to 1.

$$\lg Y = 7.58 + \underset{(43.8)}{.070S} \qquad R^2 = .067;$$

$$\lg Y = 6.20 + \underset{(72.3)}{.107S} + \underset{(75.5)}{.081j} - \underset{(-55.8)}{.0013j^2} \qquad R^2 = .285;$$

$$\lg Y = 7.43 + \underset{(75.6)}{.108S} - \underset{(18.9)}{1.087e^{-.15j}} - \underset{(-10.2)}{.426e^{-.30j}} \qquad R^2 = .320.$$ [15]

Each of these functional forms is clearly significant, with the Gompertz formulation revealing slightly more explanatory power. Nevertheless, these functions do not exhaust the available possibilities. In another context,[16] I ran regressions of earnings on a series of polynominals in j to see how they compared to the parabolic and Gompertz forms. Presumably, a high order polynomial would be sufficiently flexible to reflect patterns in the earnings profile which the two simpler equations could not encompass. White male high school graduates were selected as a typical group, and regressions were run on a random sample of approximately 1,000 individuals for the 1960 Census. These regressions revealed that the fifth power of j was the highest power which was significant. In this sample, R^2 for the parabola was .230; for the Compertz curve, .256; and for the polynomial, .266. The actual equations and the profiles they generated are shown in Figure V. As can be readily seen, the Gompertz curve shows a remarkably close fit for the first 35 years of working experience, but fails to account for the reduction in earnings late in working life. The strength of the parabolic form lies in its ability to reflect this decrease. On the basis of this test, it appears that, while neither of the simple functional forms specifies the "true" relationship between earnings and experience, the pattern of earnings over the working life conforms very closely to that predicted by a declining investment function--particularly to one which declines exponentially. Thus, both of these formulations will be retained in the analysis to follow.

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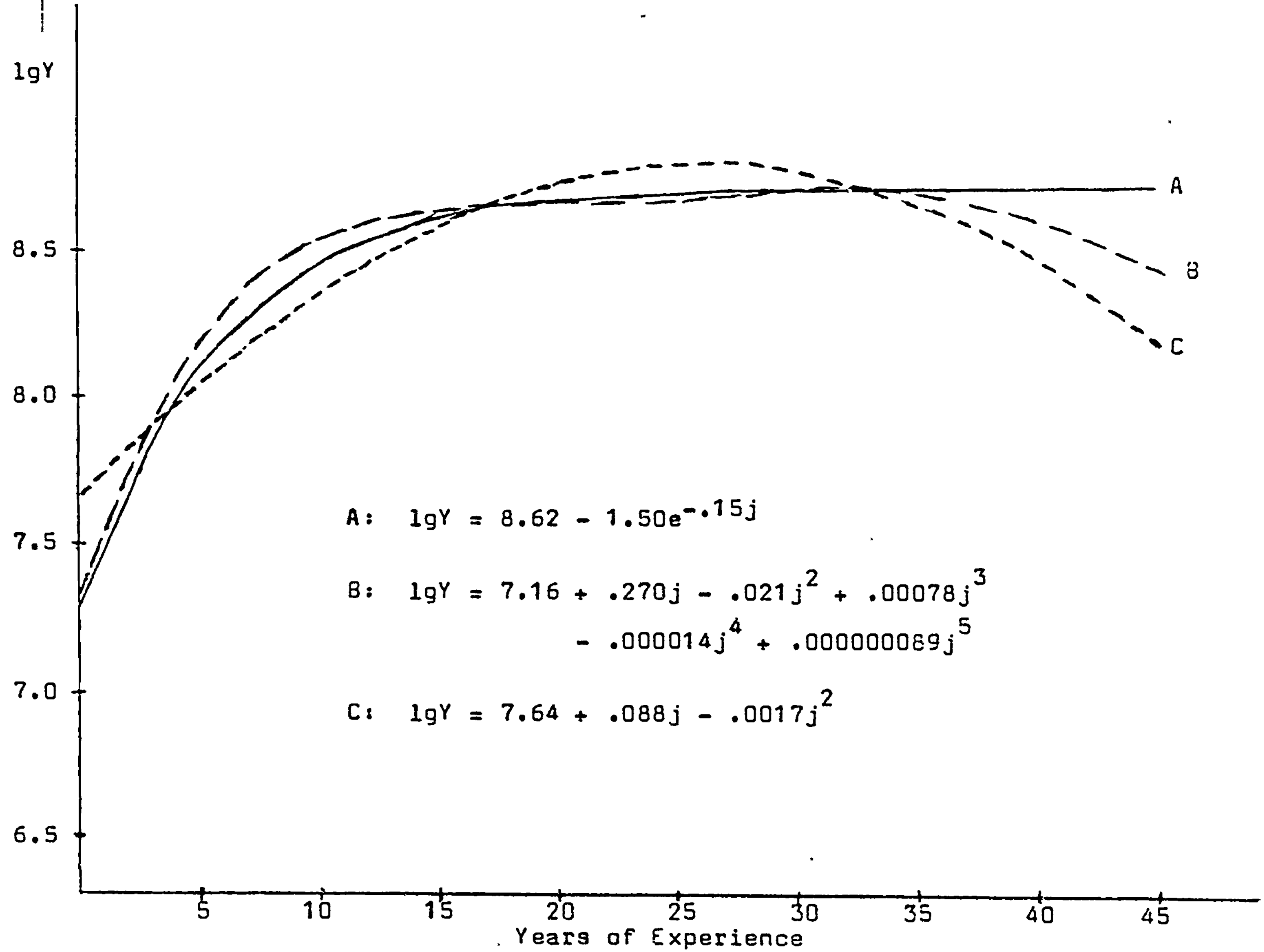
[15] Mincer, "Schooling, Age and Earnings." Figures in parentheses are t-values. Other regressions included these same equations run on men under 65, with very similar coefficients and slightly lower R^2, and regressions using $\beta = .10$, also with slightly lower R^2. Because of the close fit at investment ages, this study employes the Gompertz form exclusively.

[16] Carl M. Rahm, Investment in Training and the U.S. Occupational Structure of Earnings (New York: Columbia University, Doctoral Dissertation, 1971)

Figure 3

EARNINGS PROFILES ESTIMATED BY GOMPERTZ CURVE, POLYNOMIAL AND PARABOLA



C. Some Further Considerations

Before extending the full version of the time-investment model to an analysis of substitution between training and post-school training, it is important to consider some fundamental issues regarding the empirical nature of the time-investment model. In particular, it is necessary to analyze the extent to which the independent variables actually measure training investments.

One point which is immediately obvious is that time invested, the basic independent variable, is only an imperfect measure of resources invested. The market value of time will certainly vary among individuals. This difficulty is compounded by the assumption made that each year of formal schooling costs the individual precisely one year's potential or gross earnings. While on average this assumption is justified by the observed tendency for part-time earnings of students to just offset direct outlays for tuition expenditures (particularly at the college level), it is certainly not the case for each individual. Thus, the variation in the value of resources invested among individuals in the population can be expected to be greater than the variation in time invested.

The fact that time invested is an incomplete measure does not of itself imply, however, that it is somehow biased. So long as the amount of time invested and its market value are not strongly correlated, differences in schooling and post-school training time among a large number of individuals or groups will accurately reflect <u>average</u> differences in the value of total resources invested in training. That is, differences in investment among individuals allocating the same amount of time to a type of training tend to cancel out, but differences in investment among those allocating <u>different</u> amounts of time do not.

An additional difficulty with respect to the schooling variable is that the chronological date of school attendance varies considerably among individuals in the population. Since the content and efficiency of schooling have undoubtedly changed over time, there is clearly some question as to whether or not school years completed measures the same investment for younger and older workers. To some extent, the introduction of an experience variable will tend to capture this effect. But this then means that there is some ambiguity with regard to what the experience variable really measures.

Ambiguity arising from the changing nature of schooling is only the beginning of difficulties which result from the use of experience in the model. A related problem is that, while theoretical relationship between investment and experience is based on the individual's behavior over time, the test of the relationship is based on a crossection of individuals at different points in their working lives. As a result, there is some question as to whether or not the regressions described earlier really provide a valid test of the model. The validity of the test depends on the extent to which the crossectional earnings profile has the same structure as the (unobservable) individual longitudinal profiles. For obvious reasons, it is not possible to be certain that such is the case. Mincer, addressing himself to the same question, examined data available from a study by Herman Miller on year-to-year changes in income of workers cross-classified by age and school years completed over the decade 1956-66.[17] From these data it is possible to construct schooling group cohorts and observe average cohort longitudinal profiles over the decade. These longitudinal profiles proved to have a very similar shape to the crossection when due allowance was made for the secular growth in wages. Thus, the functional relationship established for the crossection appears to be relevant to individual longitudinal profiles as well.

A more basic question is whether or not the observed shape of the earnings profile is actually the sole consequence of post-school investment. While the shape of the profile is clearly consistent with the investment model, this consistency may be fortuitous. Much of the observed pattern, for instance, may be attributable to inherent processes of maturation by the individual, and reflect very little in the way of investment *per se*.

While such an argument is difficult to refute difinitively, given the tentative nature of available evidence, there are some bases for reply to it. First of all, Mincer's detailed study reveals that logarithmic experience-earnings profiles for different schooling groups are very similar in shape; in fact, they are nearly parallel. Age profiles, on the other hand, tend to be much less similar.[18] This represents at least *prima facie* evidence in favor of the proposition that the growth of earnings is primarily a labor market process rather than a biological one.

Mincer also refers to studies of the 1964 and 1966 earnings of economists and of the 1966 earnings of all persons reporting to the National Register of Scientific and Technical Personnel.[19] The Register collects data on years of professional experience as well as on age, schooling completed, and a number of other variables. The studies above included separate correlations of each variable with the logarithm of earnings and multiple correlations including all variables together. Among economists, simple correlations with experience and age yielded $r^2 = .41$ and $r^2 = .23$, respectively; among all scientists, the results were $r^2 = .34$ and $r^2 = .24$, respectively. The multiple correlations revealed that schooling and experience were the strongest of seven independent variables explaining earnings, and age was the weakest. Nevertheless, the independent affects of age, as revealed in this study, were not negligible, and it appears likely that the experience profile does in fact capture some biological elements as well as the investment process. Mincer suggests that perhaps one-fifth of the growth in earnings over an individual's working life might be attributable to this source.

[17] Mincer, "Schooling, Age and Earnings."

[18] *Ibid.*

[19] *Ibid.*

But with all of these defects noted, one important conclusion remains: if post-school time invested differs systematically between different groups of workers, those differences should appear in a recognizable manner in the cross-sectional experience-earnings profiles. It is this fact which this study exploits for the empirical analysis which follows.

3. Empirical Analysis

A. The Convergence Test of Substitution

Given the discussion in Section 2 above, the construction of a test for the existence of substitution between schooling and post-school training is now quite straightforward. If substitution does exist, workers in a given occupational category who have more schooling will be required to expend less time (or time equivalents) in training once they begin work. This in turn implies, ceteris paribus, that profiles measured in the logarithms of earnings of the more schooled in an occupation will tend to be less steeply inclined than those of the less schooled. Or, in other words, since the earnings profiles of less schooled workers will generally lie below the profiles of more schooled workers, the profiles will tend to converge.

This can best be illustrated by using the equation for the Gompertz curve derived in Section 2. The final form of the equation reads as follows:

$$lgY_j = LgE_0 + r_s S + r_t k_0/\beta - k_0(1 + r_t/\beta)e^{-\beta j} - 1/2\, k_0^2 e^{-\beta j} \qquad (13)$$

Assume there are two groups of workers, the first of which completes 10 years of school and the second 12 years. Assume further that we are able to obtain parameter values for the two groups such as those shown in Table 1. If we substitute these values into equation (13), we obtain the equation below.

$$\text{Group 1 (10 years of school): } lgY_j = 8.75 - 1.0e^{-.15j} - .125e^{-.30j} \qquad (14)$$

$$\text{Group 2 (12 years of school): } lgY_j = 8.80 - .5e^{-.15j} - .031e^{-.30j} \qquad (15)$$

As can readily be seen, starting earnings for group 1 are substantially below those for group 2 (for $j = 0$, Group 1 starts out about $1,700 below group 2). But as a consequence of post-school investment, the drop-out very nearly catch up to the graduates after 15 or 20 years, as the earnings profiles approach their asymptotic values. In fact, the gap ultimately closes to about $300, with the graduates earning about $6,600 per year. Only slight manipulation of our parametric values would have yielded complete overtaking.

One might observe, of course, that much the same effect on the profiles can be achieved by doubling the rate of return to post-school training (r_t) for group 1, holding training constant. In a strictly mechanical sense this is correct, although the effect on the profile of the drop-outs would not be as dramatic as the one just observed. Such wide variations in the rate of return across different job opportunities, however, would make very little economic sense. A high rate of return

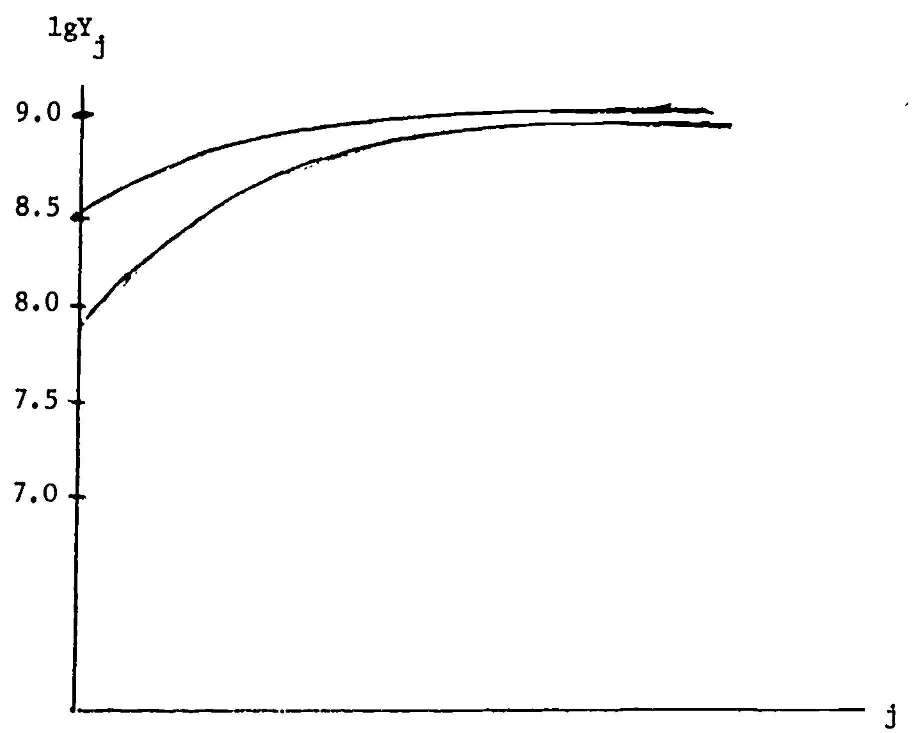
TABLE 1

HYPOTHETICAL PARAMETER VALUES
ILLUSTRATING SUBSTITUTION

Parameter	Group 1	Group 2
LgE_0	6.75	6.75
r_s	.15	.15
r_t	.15	.15
k_0	.5	.25
β	.15	.15
Y_j at $j = 0$	7.875	8.519
Y_j at $j = \infty$	9.0	9.05

FIGURE 4

HYPOTHETICAL EARNINGS PROFILES
BASED ON DATA IN TABLE 1



to one type of training would clearly encourage many individuals to make that type of investment. This response would eventually bring down the wages of workers obtaining that training and thus the rate of return to it. In fact, we can predict with some assurance that rates of return to different types of training will not vary substantially. Thus, the only variable which can cause significant differences among the shapes of the profiles of different groups of workers is post-school training.

In terms of the general formulation of the model described in Section 2, variation in the amount of post-school training is a consequence both of different initial investments and different rates of decline of investment over time. In the Gompertz curve equation, differences in initial amounts invested are reflected primarily in the coefficients of the terms $e^{-\beta j}$ and $e^{-2\beta j}$; differences in rates of decline are determined by different levels of β.

Estimation of these two parameters can be accomplished readily by means of linear regression, although in the case of β, the process is somewhat awkward. It must be done implicitly by trial and error, using the coefficient of determination (R^2) as a criterion of best "fit" as equations are run with different values of β. Interestingly, both Mincer and I found in different contexts that the goodness of fit is not too sensitive to the value of β chosen in the area of .15 or .20.[20] It appears that slight misspecification of β simply leads to a compensating adjustment in the coefficients. With respect to this study, this insensity is actually an advantage, since it makes it possible to use the same value of β for a number of regressions, while relying on the values of the coefficients to reflect differences in investment.

The outlines of a test for substitution are now clear. By fitting the Gompertz curve formulation of the time-investment model to cross-sections of workers within occupational groupings, we can (hopefully) ascertain the extent and significance of the convergence of the earnings profiles of workers completing differing amounts of schooling. But first it is necessary to examine the data used for the test.

B. The Data

The data employed for this study were taken from the Survey of Economic Opportunity conducted in 1967 by the Census Bureau for the Office of Economic Opportunity. The sample drawn for the Survey consisted of two subsamples; one of which was a random sample drawn from the U.S. population as a whole (actually, one-half of the national sample usually taken monthly by the Census Bureau), the other a special sample drawn from specified low-income census-tracts in a large number of metropolitan areas. For obvious reasons, the second subsample was of little value to this study, and no data points from it were employed.

[20] Mincer, "Schooling, Age and Earnings;" Rahm, "Investment in Training..."

The quantity of information collected for each data point in the sample was enormous; but the sample also contained the usual census information needed for this study: 1966 earnings, schooling completed, age, sex, occupation, school attendance, weeks worked in 1966, etc.

From the original data tape, I drew a final working sample which contained males from the census half-sample who were over 14, had earnings in 1966, and who were not attending school or in the military, and who were not farmers or farm laborers. This effectively limited the sample to adult males in the civilian, non-agricultural labor force in 1966.[21] Data on male workers only were used primarily because of the nature of the model employed here. Post-school investment is assumed to be a continuous process of annual accumulation after leaving school; for men, this is an assumption which corresponds closely to actual behavior, but for women, it is not. The more typical labor force pattern for women is one of intermittent labor force participation as family responsibilities change over time. Thus, their accumulation of training and skills is not continuous.

This process of elimination yielded a sample population of approximately 11,000 males, who were then subdivided into 8 major occupation groups. Finally, values of lgY, S, $e^{-\beta j}$ and $e^{-2\beta j}$ were calculated on the computer for every sample point. Years of experience, j, were determined by subtracting from each individual's age the average school leaving age for his level of schooling completed.[22] In addition, the logarithm of weeks worked was calculated for each sample point, since variation in this variable over the life cycle can be expected to exert substantial influence on the earnings profiles.

Before turning to the regressions, one last aspect of the manipulation of the data must be discussed. Throughout this study, analysis of substitution has always been expressed in terms of a single occupation. Ideally, statistical testing should be conducted within a substantial number of homogeneous occupational categories. Unfortunately, the data available (i.e., the SEO sample) do not permit the desired level of detail. In order to obtain a reasonable degree of statistical confidence, it is necessary to have over a hundred data points for each education level, or between 500 and 1,000 data points per occupation. For homogeneous groupings of roughly equal size, the SEO sample limits us to fewer than 20 occupations. After subdividing into the eight major occupation groups, however, I was at something of a loss to determine criteria for further subdivision. In fact, only four of the eight categories could have been further divided, and the two largest of those were already fairly homogeneous. I did not subdivide further. However, as the results described in the next section indicate, the lack of precision inherent in the larger groupings probably has had little effect on the results.

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[21] Farmers and farm workers were eliminated because of difficulties in measuring their real earnings.

[22] Details of the calculation process are found in Appendix I.

C. Regression Results

Linear regressions were run on each of the eight occupational subsamples. In each case the equation was of the following form:

$$\lg Y_j = a + be^{-\beta j} + c_1D_1 + c_2D_2 + \ldots + c_nD_n + d_1(D_1 \cdot e^{-\beta j}) + d_2(D_2e^{-\beta j}) + \ldots + d_n(D_ne^{-\beta j}).^{23} \qquad (16)$$

The D_i are dummy variables representing schooling groups; for each individual in the sample, the D_i took a value of 1 if the individual's level of education fell in the ith schooling class, and zero if it did not. In each of the occupational samples, there was always one level of education not represented by a dummy variable--the so-called "base group." This usually was the modal level of schooling completed in the occupation.

The effect of this procedure is to fit a set of (n + 1) regression lines within a single equation, since the dummy variables and the interaction terms ($D_ie^{-\beta j}$) allow the slope and intercept of each schooling group represented by a dummy to vary around the values of the base group. The coefficients e_i estimate the algebraic differences between the intercept values of each of the n schooling groups and base group intercept, while the coefficients d_i estimate the algebraic differences between the slopes of the n schooling groups and the slope of the base group. The standard errors of the c and d coefficients thus measure the standard errors of the differences between those coefficients and the respective base group coefficients a and b.

It is important to remember when interpreting these coefficients that they do not represent what are usually thought of as the intercept and slope. In a typical equation, such as Y = a + bX, the intercept term represents the value of Y when X equals zero; the coefficient b gives the rate at which Y increases (or decreases, if b is negative) as X increases. In the Gompertz curve form, however, the intercept term estimates the asymptotic value of Y as j approaches infinity. The value of Y when j equals zero is found by adding the coefficients a and b; when b is negative, the profile begins b units below a and rises to a.

As a consequence of this nature of the Gompertz coefficients, our procedure is efficient not only in the sense that we are able to estimate a series of profiles with a single regression, but also because it provides immediate information about the extent of convergence between the estimated profiles for two schooling groups. For example, consider two levels of school completed within an occupation, k and ℓ, where the ℓ group has completed more school. If the estimated equations indicated that a_ℓ was significantly greater than a_k, while there was no significant difference between b_k and b_ℓ, this would indicate no

[23] The second term, $e^{-2\beta j}$ was dropped from the equations. Because of the high multicollinearity between $e^{-\beta j}$ and $e^{-2\beta j}$, the estimated equations proved to be unstable with both present. Actually, in terms of estimating the profiles, the absence of the second term has little effect, and in some ways interpretation of the results is simpler.

substitution occurs: the two curves are essentially parallel. On the other hand, no significant difference between a_k and a_ℓ when b_k is significantly more negative than b_ℓ would indicate that the earnings of workers with less schooling start at a lower level than the earnings of those who have more, but eventually catch up--in other words, there is complete substitution. To generalize from these examples, we can state that convergence of profiles is always indicated if the b coefficient of a lower level of schooling is significantly more negative than that of a higher level; whether or not substitution is complete is indicated by the significance of the difference between values of the a coefficients for those two groups.

We turn now to the actual results of the test. Table 2 gives a breakdown of the eight occupational subsamples by schooling completed. As one would expect, not all schooling levels are represented in every occupation. The breakdown seen here is the result primarily of trial and error, attempting to balance the desire for a number of schooling levels against the need for a substantial number of individuals (100 or more) in each group. Some very small groups were allowed to occur in the highest or lowest education level in an occupation in order to isolate the group just below or above it (e.g., the 15 service workers with 16 or more years of schooling). No attempt was made to subdivide into education groups below 8 years of schooling, since it was not clear what the appropriate breaks might be.

Table 3 gives the estimated a and b coefficients for the different schooling groups in each occupation. These we obtained by adding the dummy and interaction coefficients to the occupational base group values of a and b in order to be able to see what the actual profiles look like. The base group is indicated under the occupational title, and the significance of the difference between the a or b coefficient of a particular schooling group and the base group is indicated by the symbols(*,",°) representing the 1%, 5% and 10% levels respectively. The actual regression equations and standard errors are found in the appendix.

Examination of these profiles occupation by occupation reveals a number of interesting results. Among professional-technical workers, for example, there are two obvious levels of substitution, both of which tend to be virtually complete: between high-school drop-outs and high-school graduates, and between college graduates and those with 17-18 years of schooling (or roughly, a master's degree). As can be readily seen from the table, substitution appears to be complete in the college graduate vs. M.A. case; it is also virtually complete in the case of high-school drop-outs and graduates, since examination of standard errors in the appendix table reveals no significant difference between the values of a for those two groups. On the other hand, there is no evidence of substitution between the high school and college levels at this occupational level, and none as well between college drop-outs and college graduates. There also seems to be little if any substitution between the college graduate-M.A. level and the group 19+, the professional degree level.

TABLE 2

COMPOSITION OF SAMPLE BY OCCUPATION AND SCHOOLING GROUPS
(fraction of occupation in parentheses)

	Number	<8	8	9-11	12	13-15	16	17-18	19+
		By Schooling Groups							
Professional and technical workers	1451		81 (.06)		239 (.16)	244 (.17)	379 (.26)	267 (.18)	241 (.17)
Managers, Officials and Proprietors	1703	102 (.06)	111 (.07)	232 (.14)	630 (.37)	313 (.18)	243 (.14)	72 (.04)	
Clerical Workers	790	85 (.11)		130 (.17)	372 (.47)	131 (.17)		72 (.09)	
Sales Worker	641	63 (.10)		79 (.12)	250 (.39)	135 (.21)		114 (.18)	
Craftsmen, etc.	2525	344 (.14)	382 (.15)	658 (.26)	928 (.37)	174 (.07)		39 (.02)	
Operatives, etc.	2497	450 (.18)	400 (.16)	727 (.29)	787 (.32)		133 (.05)		
Service Workers	735	174 (.24)	117 (.16)	150 (.20)	225 (.31)	54 (.07)		15 (.02)	
Laborers	795	244 (.31)	142 (.18)	174 (.22)	191 (.29)		44 (.05)		

TABLE 3

ESTIMATED PROFILES OF SCHOOLING GROUPS WITHIN OCCUPATION GROUPS* (transformations from dummy variables; equations of the form $\log Y_j = a + be^{-.2j}$)

Occupation (Base:)		Schooling Groups						
		<12	12	13-15	16	17-18	19+	
Professional and technical workers Base:16	a:	8.812*	8.920*	9.097*	9.296	9.225	9.461*	
	b:	-3.595*	-1.004	-1.124	-1.172	-0.641*	-0.811o	
		<8	8	9-11	12	13-15	16	+17
Managers, Officials, and Proprietors Base:12	a:	8.232*	8.411*	8.814*	9.004	9.219*	9.424*	9.410*
	b:	-3.449	+0.587	-1.628	-1.697	-1.313	-0.774*	-0.684o
		<9	9-11	12	13-15	16+		
Clerical Workers Base:12	a:	8.284*	8.636*	8.741	8.798*	8.994"		
	b:	-3.421*	-2.754+	-1.040	-1.168	-1.366		
		<9	9-11	12	13-15	16+		
Sales Workers Base:12	a:	8.082*	8.797	8.743	9.042*	9.226*		
	b:	-2.950	-3.501	-1.116	-1.317	-0.993		
		<8	8	9-11	12	13-15	16+	
Craftsmen, etc. Base:12	a:	8.257*	8.500*	8.693*	8.884	8.916	9.2[illegible]*	
	b:	-0.974	-2.747*	-1.291	-1.093	-0.735	-0.655	

*Note: Significance of difference from base group is indicated as follows: * significant at 1% or less; " significant at 5% or less; o significant at 10% or less (2-tailed test).

TABLE 3 (continued)

ESTIMATED PROFILES OF SCHOOLING GROUPS WITHIN OCCUPATION GROUPS* (transformations from dummy variables; equations of the form $\log Y_j = a + b^{-.2j}$)

Occupation (Base:)		Schooling Groups					
		<8	8	9-11	12	13+	
Operatives, etc.	a:	8.243*	8.479*	8.674	8.814*	8.910*	
Base: 9-11	b:	-2.124	-2.562°	-1.916	-1.256*	-1.394"	
		<8	8	9-11	12	13-15	16+
Service Workers	a:	7.880*	8.042*	8.472	8.538	8.619	9.024°
Base:12	b:	-2.968°	-4.169*	-2.933*	-1.475	-1.097	-2.120
		<8	8	9-11	12	13+	
Laborers	a:	7.616*	8.125°	8.330	8.494	8.404	
Base: 9-11	b:	-2.894	-3.602	3.110	-1.434*	-1.408*	

In the Manager-Proprietor group, there is very little substitution at all, unless one considers the difference between college and high school graduates. Such substitution as does exist is obviously only partial, since the difference between a coefficients is very significant.

In both the clerical and sales group, we observe again what appears to be complete substitution between high school drop-outs and graduates, although in these two groups, there is no tendency to substitution above high school. In fact in the case of clerical workers, there really is no difference at all in the profiles of high school graduates and college drop-outs--in effect, some college training has no significant effect on a clerical worker's earnings, although college graduation does. In passing, it is important to note that these two occupations are the major employers of women. It is interesting to speculate as to whether the same effects observed here for men in these occupations would also hold true for women.

Turning to the blue collar occupations, we observe a number of interesting patterns. Among the skilled crafts there is no tendency toward substitution at the high school level, although there is partial substitution between eighth grade and high school. This result is somewhat puzzling, since a substantial proportion of high school education is oriented to skilled craft training through vocational courses. There are a number of possible explanation for this phonomenon, but one feature of this occupational group which probably is at work here is the substantial extent to which craftmen are un-unionized. As unions raise wage costs to the employer, he will find it increasingly expensive to provide training on the job. The tendency will be, therefore, to hire workers with more training already completed -- that is, graduates rather than drop outs. The effect of this will be to separate drop-outs from graduates and, in a sense, put them on separate tracks. As a consequence, the tendency for substitution between the two modes of training would be diminished.

Among the three remaining blue collar groups, the characteristics that stands out most strikingly is the substitution between partial completion of high school and graduation. Substitution is incomplete in the case of operatives, although the final earnings differential (as measured by $a_{12} - a_{q-11}$) is small; it appears to be virtually complete among service workers and laborers. In every case, substitution beyond high school is non-existent (as indicated in the appendix tables, the b coefficients for 13+ years of school do not differ significantly from those for 12 years); partial substitution between eighth grade and some high school appears among serviceworkers, but not among operatives or laborers.

While the results above are highly indicative of a substantial amount of substitution, particularly between high school drop-outs and high school graduates, there are a number of elements in these results which are slightly disturbing. One particularly is the size of many ofthe coefficients, which are often much larger than seem to be indicated by the illustrative calculation done in part A of this section. Part of this, of course, is due to the fact that we collapsed the two terms into one. In effect our a coefficients are doing double duty, and as such, will tend to be large. Nevertheless, there is another factor present which has much the same effect -- variation in number of weeks worked. Unemployment tends to fall most heavily on the unskilled, who in turn tend to be young. Since our data measures annual income, systematic variation of unemployment with age will tend to make the profiles steeper than they otherwise would be.

Systematic variation in unemployment with skill might also mean that our test of substitution is spurious. If low skilled -- i.e., low educated -- workers are laid off more readily, then convergence of profiles could result from this factor alone. To check on these two possibilities, I redid the regression analysis in terms of weekly earnings. This was accomplished by assuming that weekly earnings bear the same relationships to training that annual earnings do. Thus:

$$\lg(Y_j/wks_j) = a' + be^{-\beta j} \quad (17)$$

$$\lg Y_j \; \lg wks_j = a' + be^{-\beta j} \quad (18)$$

$$\lg Y_j = a' + be^{-\beta j} + f \cdot \lg wks. \quad (19)$$

The coefficient a' now measures a weekly earnings base, while the coefficient f is introduced to allow for systematic variation in the weekly wage with weeks worked.

The result of running regressions of this form is seen in Table 4 and appendix Table 2. A quick perusal of these two tables reveals that the b coefficients are indeed much smaller. Systematic variation in weeks of employment with experience does tend to steepen the profiles. But, the conclusions regarding substitution are basically unaffected. In fact, if anything, the results are somewhat strengthened.

4. Summary and Conclusions:

Briefly stated, we have examined in a general way the phenomenon of substitution between schooling and post school training in eight major occupational groups. The basic hypothesis was that if the two training modes are substitutes, than experience -- earnings profiles measured in the logarithm of earnings should tend to converge. Statistical testing revealed a very strong tendency in six of eight occupation groups for almost complete substitution to occur between the post-school training of high school grop-outs and the additional formal education of those who left school after obtaining a high school diploma. Some substitution appears to exist as well at the college level, with substitution between the schooling of professionals who obtain an M.A. (approximately) and the post school training of those who stop at the B.A. being most marked.

If there results are to be believed, then they lead to an important conclusion -- dropping out may be perfectly rational from the point of view of both the individual and society. The returns earned on one or two additional years of education at thei high school level for those not continuing their education more often than not are due to an acceleration of training which can be obtained through work experience. In other words, the drop-out is not sacrificing his education, but pursuing it in a different manner. Obviously, this is not to suggest that high school

TABLE 4

ESTIMATED PROFILES OF SCHOOLING GROUPS INCLUDING LOGARITHM OF WEEKS WORKED

(transformations from dummy variables; equations of the form $\log Y_j = a + be^{-.2j}$)

Occupation (Base:)		Schooling Groups							lgWks Worked
		<12	12	13-15	16	17-18	19+		Wks
Professional and technical workers Base:16	a:	4.433*	4.541	4.667*	4.877	4.836	5.070*		1.121
	b:	-1.428°	-0.596	-0.742	-0.750	-0.427°	-0.794		
		<8	8	9-11	12	13-15	16	17+	
Managers, Officials, and Proprietors Base:12	a:	4.539*	4.625*	5.011*	5.183	5.391*	5.579*	5.565*	
	b:	-3.358	+0.029	-1.402	-1.572	-1.246	-0.740"	-0.706°	
		<9	9-11	12	13-15	16+			Wks
Clerical Workers Base:12	a:	3.910*	4.151	4.191	4.246	4.382*			1.161
	b:	-1.231°	-1.458*	-0.5854	-0.263°	-0.187°			
		<9	9-11	12	13-15	16+			Wks
Sales Workers Base:12	a:	2.675*	3.125	3.117	3.326"	3.592*			1.454
	b:	-2.254*	-2.633*	-1.062	-0.724	-0.625			
		<8	8	9-11	12	12-15	16+		Wks
Craftsmen, etc. Base:12	a:	3.909*	4.086*	4.171*	4.284	4.302	4.657*		1.180
	b:	-1.527	-1.804"	-0.875	.731	.311°	.638		
		<8	8	9-11	12	13+			Wks
Operatives Base:9-11	a:	4.144*	4.294*	4.430	4.527*	4.605*			1.092
	b:	-1.610°	-1.590°	-1.148	-0.714*	-0.803°			

TABLE 4 (continued)

ESTIMATED PROFILES OF SCHOOLING GROUPS INCLUDING LOGARITHMIC OF WEEKS WORKED

(transformations from dummy variables; equations of the form $\log U_j = a + be^{-.2j}$)

Occupation (Base:)		Schooling Groups						lgWks Worked
		<8	8	9-11	12	13-15	16+	Wks
Service Workers	a:	3.450	3.524*	3.867	3.910	4.038	4.228	1.189
Base:12	b:	-1.735	-2.432*	-1.556*	-0.724	-0.180	-0.288	
		<8	8	9-11	12	13+		Wks
Laborers	a:	3.032*	3.316°	3.492	3.496	3.507		1.300
Base:9-11	b:	-1.810	-2.098	-1.507	-0.599*	+0.270*		

completion is not worthwhile -- only that not pursuing it need not be a mistake.

Finally, however, I must make a disclaimer. The results here are not the last word. As is true of every research project, I have only provided some evidence to be weighed against that provided by others. Final conclusions must rest with all the evidence.

Appendix

Derivation of the Data

The data found in the survey of economic opportunity were especially well suited to this study, since most of the variables used in the analysis were measured in exact values, rather than in ranges. Their age and schooling completed were by single year, and earnings data were to the nearest $10 up to $99,990.

The variable weeks worked in 1959 was presented on the tape in the form of fairly broad classes: 0, 1-13, 14-26, 27-39, 40-47, 48-49, and 50-52 weeks. Individuals with zero weeks were excluded and the remaining categories were assigned the following values: 7, 20, 33, 44, 49, and 52 weeks. The last three categories were given higher than mid-point values because of the acute upward slope of the frequency histogram of these classes after 40 weeks. Natural logarithms of these six values comprise the data for lgWks in the regressions.

The variable experience was calculated by subtracting from each individual's age the average age of labor force entry which corresponded to his schooling completed. Labor force entry ages were derived from Prof. Hanoch[1] who calculated the average age of students at various grade levels and thus added one year. The entry ages used by education category were as follows:

Schooling:	0-6	7	8	9-10	11	12	13-15	16	17+
Entry Age:	14	15	16	17.5	19	20	22.5	25	28

Entry ages for single years found in ranges such as 9-11 were interpolated.

The two tables on the following pages give the actual estimated regression equations and standard errors of the estimater.

[1]Hanoch, "En Economic Analysis of Earning's and Schooling."

TABLE A1

REGRESSIONS OF 1966 EARNINGS ON GOMPERTZ FORMULATION OF
EXPERIENCE WITH VARIOUS SCHOOLING DUMMY VARIABLES AND INTERACTION TERMS
(standard errors in parentheses)

Occupation* (Base Group) (Sample Size)	Intercept and Base Coefficient	Dummy and Interaction Coefficients for Specified Schooling						
			<12	12	13–15	17–18	19+	R^2
Professional and technical workers Base:16	9.296 (.038)		-0.484 (.081)	-0.375 (.059)	-0.198 (.060)	-0.071 (.059)	0.165 (.061)	.21
	-1.172 (.120)		-2.423 (.442)	0.168 (.265)	0.048 (.258)	0.531 (.201)	0.361 (.198)	
		<8	8	9–11	13–15	16	17+	R^2
Managers, Officials, and Proprietors Base:12	9.004 (.029)	-0.772 (.074)	-0.593 (.072)	-0.190 (.055)	0.215 (.051)	0.420 (.057)	0.406 (.099)	.20
	-1.697 (.269)	-1.752 (1.907)	2.281 (3.209)	0.069 (.812)	0.368 (.384)	0.923 (.368)	1.013 (.548)	
			<9	9–11	13–15	16+		R^2
Clerical Workers Base:12	8.741 (.039)		-0.456 (.084)	-0.104 (.076)	0.058 (.081)	0.254 (.102)		.26
	-1.040 (.154)		-2.382 (.552)	-1.715 (.324)	-0.129 (.270)	-0.327 (.323)		
			<9	9–11	13–15	16+		R^2
Sales Workers Base:12	8.743 (.058)		-0.661 (.124)	0.054 (.118)	0.299 (.010)	0.483 (.108)		.35
	-1.116 (.264)		-1.834 (.498)	-2.385 (.382)	-0.199 (.424)	-0.123 (.383)		

TABLE (continued)

REGRESSIONS OF 1966 EARNINGS ON GOMPERTZ FORMULATION OF EXPERIENCE WITH VARIOUS SCHOOLING DUMMY VARIABLES AND INTERACTION TERMS
(standard errors in parentheses)

Occupation* (Base Group) (Sample Size)	Intercept and Base Coefficient	Dummy and Interaction Coefficients for Specified Schooling					
		<8	8	9-11	13-15	16+	R^2
Craftsmen, etc. Base:12	8.884 (.025)	-0.627 (.045)	-0.384 (.043)	-0.192 (.038)	0.031 (.064)	0.385 (.129)	.12
	-1.093 (.142)	0.119 (.805)	-1.654 (.651)	-0.198 (.266)	0.358 (.306)	0.437 (.396)	
		<8	8	13	13+		R^2
Operatives Base:9-11	8.674 (.026)	-0.431 (.040)	-0.195 (.042)	0.140 (.038)	0.237 (.074)		.23
	-1.916 (.131)	-0.208 (.356)	-0.646 (.352)	0.660 (.155)	0.522 (.213)		
		<8	8	9-11	13-15	16+	R^2
Service Workers Base:12	8.538 (.060)	-0.658 (.087)	-0.496 (.097)	-0.067 (.093)	0.082 (.135)	-0.487 (.268)	.31
	-1.475 (.212)	-1.494 (.717)	-2.695 (.559)	-1.458 (.369)	0.377 (.542)	-0.646 (.602)	
		<8	8	12	13+		R^2
Laborers Base:9-11	8.330 (.096)	-0.714 (.120)	-0.205 (.136)	0.164 (.136)	0.074 (.241)		.25
	-3.110 (.290)	0.217 (.648)	-0.491 (.659)	1.677 (.375)	1.702 (.476)		

TABLE A2

REGRESSIONS ON GOMPERTZ FORMULATION WITH SCHOOLING
DUMMY VARIABLES AND INTERACTION TERMS PLUS lg (WEEKS WORKED)
(standard errors in parentheses)

Occupation* (Base Group) (Sample Size)	Intercept and Base Coefficient	Dummy and Interaction Coefficients for Schooling Groups						lgWks Worked	R^2
			<12	12	13-15	17-18	19+	Wks	R^2
Professional and technical workers Base: 16	4.877 (.251)		-0.444 (.074)	-0.336 (.053)	-0.210 (.054)	-0.041 (.053)	0.193 (.055)	1.121 (.063)	.35
	- .750 (.111)		-0.777 (.411)	0.154 (.240)	0.008 (.234)	0.333 (.182)	-0.044 (.181)		
		<8	8	9-11	13-15	16	17+	Wks	R^2
Managers, Officials, and Proprietors Base:12	5.183 (.285)	-0.644 (.072)	-0.558 (.069)	-0.172 (.053)	0.208 (.049)	0.396 (.054)	0.382 (.095)	0.976 (.073)	.28
	-1.572 (.256)	-2.786 (1.814)	1.543 (3.051)	0.170 (.772)	0.326 (.365)	0.832 (.350)	0.866 (.521)		
			<9	9-11	13-15	16+		Wks	R^2
Clerical Workers Base:12	4.191 (.176)		-0.281 (.062)	-0.040 (.055)	0.055 (.059)	0.191 (.074)		1.160 (.044)	.61
	-0.583 (.114)		-0.645 (.049)	-0.873 (.239)	0.322 (.198)	0.398 (.237)			
			<9	9-11	13-15	16+		Wks	R^2
Sales Workers Base:12	3.117 (.273)		-0.442 (.094)	0.008 (.089)	0.209 (.075)	0.475 (.082)		1.454 (.070)	
	-1.062 (.199)		-1.092 (.389)	-1.571 (.298)	0.338 (.325)	0.437 (.297)			

TABLE (continued)

REGRESSIONS ON GOMPERTZ FORMULATION WITH SCHOOLING DUMMY VARIABLES AND INTERACTION TERMS PLUS lg (WEEKS WORKED)
(standard errors in parentheses)

Occupation (Base Group) (Sample Size)	Intercept and Base Coefficient	Dummy and Interaction Coefficients for Schooling Groups					lgWks Worked	R^2
		<8	8	9-11	13-15	16+	Wks	R^2
Craftsmen, etc. Base:12	4.284 (.105)	-0.375 (.034)	-0.198 (.033)	-0.113 (.028)	0.018 (.048)	0.373 (.097)	1.180 (.027)	.51
	-0.731 (.107)	-0.796 (.603)	-1.173 (.488)	-0.144 (.199)	0.420 (.229)	0.093 (.297)		
		<8	8	12	13+		Wks	R^2
Operatives Base:9-11	4.430 (.106)	-0.286 (.031)	-0.126 (.032)	0.097 (.029)	0.176 (.058)		1.092 (.027)	.54
	-1.148	-0.462 (.103)	-0.442 (.276)	0.434 (.273)	0.345 (.120)			
		<8	8	9-11	13-15	16+	Wks	R^2
Service Workers Base:12	3.910 (.199)	-0.460 (.065)	-0.386 (.073)	-0.043 (.069)	0.128 (.101)	0.318 (.200)	1.189 (.050)	.61
	-0.724 (.161)	-1.010 (.536)	-1.708 (.420)	-0.832 (.277)	0.544 (.405)	0.436 (.452)		
		<8	8	12	13+		Wks	R^2
Laborers Base:9-11	3.492 (.181)	0.460 (.084)	-0.176 (.095)	-0.005 (.095)	0.015 (.168)		1.300 (.045)	.64
	-1.507 (1.210)	-0.304 (.452)	-0.591 (.460)	0.908 (.263)	1.777 (.332)			