Implicit Investment Profiles and Intertemporal Adjustments of Relative Wages

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The human capital model (see Gary Becker and Jacob Mincer, 1970) is appealing because it introduces a theoretical explanation of earnings differentials that is consistent with rational behavior on the parts of the actors. Nevertheless, the theory is not completely satisfactory because it is built upon unobserved quantities, namely human capital, and the observable implications of this theoretical structure are generally consistent with a variety of other explanations. One objective of this analysis is to consider more directly the implied investment behavior of workers, since it is at that level that human capital theory diverges from alternative theories.

In principle, the relevant tests of the theory relate observations on individual investment activities to earnings patterns over time. However, the absence of direct observation on investment and of longitudinal data on individuals has led to behavioral models developed for and analyzed using cross-sectional data. The specification of the model in cross-sectional terms, however, requires a number of very strong assumptions and precludes estimation of many key parameters of the underlying model. Thus our second objective is to expand the conceptual model to address intertemporal dynamics and to analyze short-run variation in the returns to human investment.

Finally, the stability of earnings profiles over time is a subject of interest in itself. A number of past studies of the rates of return to schooling indicate some instability in the estimates when they are made at different points in time (see Becker, Richard Freeman, Giora Hanoch, and W. Lee Hansen). Such intertemporal differences are often explained by appeal to some sort of aggregate adjustment over a particular interval (see Freeman and Anders Klevmarken). However, the exact nature of these changes and their relationship to rates of return on human capital investment for different subpopulations are never clearly articulated.

This paper begins by extending the model of human capital accumulation to distinguish between the effects of labor market experience and aging on observed earnings profiles, to incorporate other individual differences explicitly, and to incorporate short-run dynamics. On this basis, the implied postschool investment profiles are then estimated, and the impact of aggregate economic conditions on earnings profiles is considered.

I. The Conceptual Model

Typically, human capital models applied to earnings differences begin with a simple description of the investment behavior of a single individual, and then make a series of strong assumptions about the homogeneity of individuals and the pattern of dynamic economic changes so that empirical tests can be conducted with a cross section of individuals. While several problems with this research strategy have been noted (see Alan Blinder and Mincer, 1974), such highly stylized models have led to empirical analyses in which the underlying investment parameters are generally unidentified. In particular, empirical models often estimate earnings as a function of schooling and some transformation of age—a model which is consistent with many "stories" about the labor market, not just a model of human

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capital investment. This section expands the basic conceptual framework and demonstrates how information about the implied investment schedules and about labor market dynamics can be unraveled.

In its simplest static form (for example, see Mincer, 1974), the human capital model postulates that

$$(1) \qquad E_n = E_{n-1} + r_{n-1}C_{n-1}$$

where E_n is the potential earnings of an individual with n years of experience (i.e., the earnings obtainable if no resources are used for investment in human capital in the nth year); C_{n-1} is the amount of human capital investment in the $n-1$ year of experience, and r_{n-1} is its corresponding rate of return. In terms of an "investment ratio," k_n, at any year of experience (defined as the ratio of gross investment to potential earnings, i.e., C_n/E_n), equation (1) may be represented as

$$(2) \qquad E_n = E_{n-1}(1 + r_{n-1}k_{n-1}) = E_0 \prod_{j=0}^{n-1} (1 + r_j k_j)$$

If we assume that the rate of return is constant ($r_j = r$) and that the terms rk_j are small, a Taylor series approximation of (2) is

$$(3) \qquad \log E_n \simeq \log E_0 + r \sum_{j=0}^{n-1} k_j$$

If we further assume that all investment comes in the form of reduced earnings, such that $E_n = Y_n + C_n$ where Y_n is observable income, then, by a similar approximation,

$$(4) \qquad \log Y_n \simeq \log E_0 + r \sum_{j=0}^{n-1} k_j - k_n$$

Equation (4) states that the observed earnings of a worker with n years of experience are related in a simple way to his initial potential earnings, the return on all previous capital investments, and his investment decision in year n.

The exact specification of the investment profile is crucial to any empirical analysis. For a variety of well-known reasons (see Yoram Ben-Porath, 1967, 1970; Blinder and Yoram Weiss; William Haley; James Heckman; Sherwin Rosen), the rational investor will reduce his human capital investment over his lifetime, but the exact shape of the profile cannot be deduced from theory.[1] A common thread in the conceptual discussions is that postschooling investment should be related to the labor market experience of the individual. In this analysis, we assume that the investment ratios (k_n) for postschooling investments decline linearly with actual labor force experience. While this precise form is not derived from a particular lifetime utility-maximization model, it has been shown in at least one recent study (see Klevmarken and Quigley) to be a reasonable empirical approximation to a completely general lifetime investment schedule; it offers the considerable advantages of parsimony and tractability in empirical work; and it has been used quite commonly in past research (see, for example, Mincer, 1970).

To see the implications of this assumed investment path, let n = years since completion of schooling (potential experience), and λ_m^i = the proportion of the mth elapsed year spent in work activity by individual i. Then the accumulated experience at the nth year of potential experience, a_n^i, is

$$(5) \qquad a_n^i = \sum_{m=0}^{n-1} \lambda_m^i$$

and the assumed investment path is given by

$$(6) \qquad k_j = A + Ba_j^i$$

with $0 < A < 1$ and $B < 0$

Even with this simple investment schedule, calculation of total investment (for use in (4)) generally requires knowledge of the entire past history of labor market experience. However, this information is not required in two specific cases. If all individuals are fully employed in all years after school ($\lambda^i = 1$), actual experience equals potential

[1]Theoretical results depend crucially upon the production function for human capital, for which there is no evidence. See, for example, Haley.

experience (a linear transformation of age), and substitution into (4) indicates that the *log* of observed earnings is a quadratic function of potential experience. This has become a quite common specification of earnings functions, largely because many convenient data sets provide information about workers' ages, but not about their labor market experiences. Unfortunately the effects of aging and labor market experience are completely intertwined, and the parameters of interest (A, B, and r) are unidentified.[2] The only refutable hypotheses in this form are that the coefficients on the linear and squared potential experience terms are positive and negative, respectively. But few people would believe that the signs of these coefficients offer a very powerful test of the validity of the underlying model.

While complete data about the profile of individual labor market experiences may be unavailable, information about total labor market experiences can be incorporated into this model in a more general case. If each worker devotes a fixed proportion of each year to labor market activities ($\lambda_j^i = \lambda^i = a_n^i/n^i$), the resulting specification of (4) in terms of observable variables becomes

$$(7)\quad log\ Y_n^i = log\ Y_0 + [rA]n^i + \left[\frac{rB}{2}\right]n^i a_n^i - \left[\frac{rB}{2} + B\right]a_n^i$$

[2]The resultant model in terms of observable variables is:

$$log\ Y_n = log\ Y_0 + r\left(A - \frac{B}{2} - \frac{B}{r}\right)n + \frac{rB}{2}n^2$$

One way of identifying the underlying parameters is the following: assume that $k_t = 1$ during schooling and the investment function in equation (6) begins at the end of schooling; then it is possible to separate out a term rS where S is years of schooling. If the rate of return on schooling equals the rate of return on post-school investments, the other parameters of the investment function can be identified (see Mincer, 1974). However, there is little a priori reason to assume that these returns are the same. Further, since it appears that the return to schooling varies by schooling level (see Hanoch), the assumption is open to more serious question—since it is not even clear which schooling rate of return should be used.

Importantly, by incorporating information about cumulative labor market activities, the underlying parameters can now be identified, even in a single cross section, and the implied investment profiles can be estimated.

A second concern with this model is the static assumption underlying conventional analysis. There are exogenous changes in available capital, productivity, and organization; more generally, the fruits of economic growth are certainly reflected in the time path of earnings received by workers, as are short-run shifts in the supplies and demands for workers in given educational levels. This implies that the lifetime income profile of a cohort of identical workers will differ from (and in general be less concave than) the cross-sectional earnings pattern of otherwise identical workers with differing experience levels.

To recognize these dynamic factors, assume that the earnings profiles of a particular group (say, individuals in the same race/sex/schooling class) are shifted proportionately as a result of changes in productivity, organization, etc., and in response to short-run excess demands for a particular class of labor. Let $\exp\{b_m\}$ be the growth of earnings due to these factors at year m; this yields

$$(8)\quad \begin{aligned} E_{n,t} &= E_{n,t-1}\exp\{b_{t-1}\} \\ &= E_{n,p}\exp\left\{\sum_{m=p}^{t-1} b_m\right\} \\ &= E_{n,p}\exp\{\beta_{t-1,p}\} \end{aligned}$$

where $\sum_{m=p}^{t-1} b_m = \beta_{t-1,p}$

and the second subscript on earnings signifies real time.

Together, (7) and (8) provide a model of the systematic variation in the earnings of a representative individual over his lifetime. However, the potential earnings of individuals with identical schooling, age, and experience clearly vary due to other systematic as well as random influences. We can describe differences in individual profiles as

(9) $$E^i_{0,t} = E_{0,t} \exp \{X^i\gamma + \mu^i\}$$

where $E^i_{0,t}$ is the potential earnings of an individual in a given schooling class at entry into the labor force, X^i is a vector of systematic differences in earnings profiles due to other measured characteristics of individuals (such as measures of ability or physical handicap), and μ^i is an individual-specific stochastic term which represents a composite of unmeasured attributes (such as quality differences in schooling, attitudes, motivations, or pure luck) which affect the individual's earnings over his lifetime. In addition to these predetermined factors, an individual's observed earnings at any point may depart from his own profile as

(10) $$Y^i_{n,t} = \tilde{Y}^i_{n,t} \exp \{\nu^i_t\}$$

where $\tilde{Y}^i_{n,t}$ is the expected earnings for an individual and ν^i_t is a stochastic term.

Combining these aspects of earnings yields a testable form of the human investment model which depicts the dynamic earnings path of a class of individuals:[3]

(11) $$\log Y^i_{n,t} = \log \tilde{Y}^i_{0,p} + \beta_{t-1,p} + [rA]n^i + \left[\frac{rB}{2}\right] n^i a^i_n - \left[\frac{rB + B}{2}\right] a^i_n + X^i\gamma + \mu^i + \nu^i_t$$

As specified in equation (11), the logarithm of earnings for an individual of a given schooling class is linearly related to his potential experience (n, the number of elapsed years since school completion), his total labor market experience (a_n, the accumulation of the time spent actually working), and their interaction ($a_n n$), corrected for the vector (X) of systematic differences in ability, etc., and for intertemporal shifts (β) in the earnings profile of his class. The model includes an individual specific error term as well as a more conventional stochastic term which varies by individual and time period. The full model in (11) can be estimated from panel data on individuals that includes measures of earnings or wage rates, schooling, age, and actual labor market experience. If we assume that these errors are normally distributed with zero mean and

$$\begin{aligned} E(\mu^i\mu^j) &= \sigma^2_\mu \quad \text{if} \quad i = j \\ &= 0 \qquad\quad i \neq j \\ E(\nu^i_t\nu^j_\tau) &= \sigma^2_\nu \quad \text{if} \quad i = j, t = \tau \\ &= 0 \quad \text{otherwise} \end{aligned}$$

then the specification follows the general error components form (see T. D. Wallace and A. Hussain).[4]

The model specification in (11) uses differences across individuals in the accumulation of labor market experience to provide information about the underlying investment profiles and the rates of return to postschool investments. Further, it provides additional information about how earnings profiles shift over time. Finally, the stochastic specification permits a direct test of the importance of unmeasured in-

[3]A series of cross sections in which individuals are not linked is sufficient for estimating all but the error components structure; a single cross section implies the β's and error components cannot be estimated; and missing information about actual labor force experience implies that only the model in fn. 2 can be estimated. Conceptually, two considerations define the appropriate stratifications for analysis: the investment schedule considers only postschooling investment and the dynamics relate to shifts for homogenous groups. Therefore, by stratifying into schooling groups, in empirical analysis, earnings differences due to schooling differences are implicitly included in different intercepts. Important dynamic changes include differences among schooling/race/sex groups.

[4]The error components model, which provides more efficient estimates, is estimated by generalized least squares. This specification assumes that the individual component μ^i for different individuals is drawn from a common distribution with a mean of zero. In this specification, the individual component is fixed. This may be unrealistic over a lifetime but is a reasonable approximation over a limited period of time such as the seven years of data used in this work; empirically this specification was found to be virtually identical to estimates which also allow for individual serial correlation in the errors (see Lee Lillard and Robert Willis). Additionally, this specification assumes that the error components (μ^i and ν^i_t) are independent of each other and of the exogenous variables in the model. Finally, the actual estimation procedure differs from that in Wallace and Hussain because all the individuals are not observed for the same number of time periods; this requires a correction in the estimation of ρ, the proportion of residual variance arising from unmeasured differences in individuals.

dividual differences which systematically affect earnings relative to those factors postulated by economic theory.

The appropriate measure for the dependent variable in the theoretical analysis is somewhat unclear. Most previous analyses of human capital have used annual earnings (i.e., total income from labor) as the measure of the dependent variable. To be sure, due to problems of data availability, this has not always been a free choice, yet the implications of this choice are seldom discussed.

There is a fundamental distinction between physical capital and its counterpart imbedded in human beings. The wage rate plays a dual role; it simultaneously represents the return on human capital and the price at which work is substituted for leisure. Because work presumably involves some disutility, the amount of investment in human capital can, indeed will, affect its rate of utilization.

If an individual varies his labor supply as a function of his wage rate, an analysis of annual earnings could give quite misleading impressions of the returns to human capital. The rate of return is calculated with respect to an unobserved stock of human capital, so a given annual earnings can be consistent with either a large stock of capital and a low utilization rate or with a small stock of capital utilized intensively.

Alternatively, individual wage rates can be used as the dependent variable. The theory requires measuring the increase in productivity that is associated with increased investment. The wage rate (in a competitive economy) may be interpreted simply as the productivity associated with a given stock of human capital at a standard utilization rate. This measure of productive capacity seems more within the spirit of the capital investment model, and in the empirical section below we emphasize wage rates. In principle, however, joint estimation of labor supply and wages would be still preferable.[5]

II. Empirical Results

The models described above are estimated using panel data from the Michigan Panel Study on Income Dynamics, which provide annual earnings, wages, and information on personal characteristics for individuals in a sample of about 5,000 households during the period 1968–74. The analysis presented here concentrates upon males, age 16–60 in 1968.[6]

Tables 1 and 2 present estimates of the parameters of equation (11) separately for white and black workers of three schooling classes (0–8 years, 9–12 years, and 13 or more years), with the *log* of wages as the dependent variable.[7] For each stratification, dummy variables are included to reflect the completion of a particular level: at least six years; high school graduation; college graduation; postgraduate education. Three

[5]Similar considerations, but a different standardization, are noted in Richard Eckaus. Using wage rates does neglect any possible effect of utilization on productivity and could understate the private (but not social) return on investments to the extent that part of the returns come from less involuntary unemployment. Theoretical developments of models with endogenous wage rates and labor supply require far more stringent assumptions to arrive at an analytical solution (see Heckman and Haley) and are yet to be developed to a point of empirical usefulness. In the empirical section below, we report results using wage rates. We also note any differences when annual earnings are used. Results estimated from annual earnings are available on request.

[6]The analysis is confined to males since the labor force participation decision cannot reasonably be considered exogenous for females (as we implicitly assume). Individuals at or nearing retirement were also excluded. There were 2,793 males in the original sample who met the age restrictions and who were not retired during the sample period. A total of 372 of these were eliminated from the sample because they were neither white nor black or because other data were missing. The sample includes 1,766 white workers and 655 blacks. Individuals are included in the sample only if they had positive earnings for at least three of the possible seven years. The average number of time-series observations for individuals in the sample is 6.27 out of a possible 7 periods.

[7]The average hourly wage rate was estimated by dividing gross labor earnings by the reported (annual) hours worked. There is obviously a large component of measurement error in this computation. However, as compared with models of annual earnings (see fn. 5), the estimated coefficients are generally more precise and the overall explanatory power of the models is slightly higher.

TABLE 1—WAGE MODELS FOR WHITE MALES[b]

Variable	Elementary School	High School	College	Pooled
Schooling Completion				
6-8 years	−.0854			−.0138
	(.8746)			(.1518)
12 years		.1098		.1249
		(3.4772)		(1.3206)
16 years			.2599	.2765
			(6.9561)	(2.8173)
More than 16 years			.3732	.3922
			(7.3240)	(7.7868)
Other characteristics: X^i				
Ability score	.0022	.0350	.0224	.0245
	(.1819)	(4.4961)	(2.1016)	(4.3959)
Health Limitation	−.0321	−.0636	.0026	−.0394
	(1.0274)	(3.3968)	(.0975)	(2.8758)
South	−.1048	−.0372	−.0045	−.0357
	(3.1968)	(2.1936)	(.2018)	(2.8849)
Interaction $a_n^i \cdot n^i / 10^2$	−.0768	−.0857	−.1159	−.0923
	(5.1231)	(11.9484)	(11.5974)	(18.7482)
Actual Experience: $a_n^i / 10$	.4909	.3253	.4260	.4085
	(4.9270)	(4.7890)	(4.9267)	(8.9660)
Potential Experience: $n^i / 10$	−.0961	.1305	.1740	.0889
	(1.1399)	(2.0532)	(2.1455)	(2.1078)
Intercept				
Elementary school	.6205			.1554
	(3.1943)			(1.4629)
High School		.2102		.1184
		(2.5292)		(1.2815)
College			.4532	.3316
			(3.8246)	(3.4570)
β_{69}	.1089	.0660	.0899	.0798
	(3.529)	(4.102)	(4.193)	(6.7154)
β_{70}	.2090	.1450	.1379	.1520
	(6.737)	(9.088)	(6.525)	(6.2636)
β_{71}	.2518	.2052	.2012	.2110
	(7.988)	(12.873)	(9.527)	(12.0500)
β_{72}	.3515	.2884	.2388	.2811
	(10.882)	(17.973)	(11.284)	(11.3504)
β_{73}	.3334	.3620	.3294	.3505
	(9.400)	(21.691)	(15.041)	(16.8503)
β_{74}	.4599	.4295	.3838	.4209
	(12.304)	(24.644)	(16.864)	(19.1455)
R^2	.1716	.2526	.2503	.2496
ρ	.6432	.6394	.5904	[a]
σ^2	.3240	.2430	.2729	[a]
σ_μ^2	.2080	.1550	.1630	[a]
σ_ν^2	.1160	.0880	.1100	[a]
Number of observations	1685	5483	4029	11197
Number of individuals	251	873	642	1776

[a]Equations were pooled using the values of ρ estimated for each of the subpopulations.

[b]The total error variance is decomposed into an individual specific and a purely random component. These estimated error components are subsequently used in a generalized least squares estimation procedure (Wallace and Hussain). The components are defined as follows: σ^2 = estimated total error variance; σ_μ^2 = estimated individual specific error variance, i.e., variance of μ_i; $\sigma_\nu^2 = \sigma^2 - \sigma_\mu^2$ = purely random error variance; and ρ = proportion of total error variance which is individual specific $= \sigma_\mu^2/\sigma^2 = \sigma_\mu^2/(\sigma_\mu^2 + \sigma_\nu^2)$. t-statistics in parentheses.

TABLE 2—WAGE MODELS FOR BLACK MALES[b]

Variable	Elementary School	High School	College	Pooled
Schooling Completion				
6–8 years	−.0454			−.0621
	(.5985)			(.9026)
12 years		.1795		.2214
		(4.3839)		(2.9231)
16 years			.1644	.1741
			(1.3837)	(1.2887)
More than 16 years			.6443	.5148
			(4.9253)	(4.2544)
Other characteristics: X^i				
Ability score	.0369	.0203	.0211	.0279
	(2.9296)	(2.6110)	(1.2224)	(4.5541)
Health Limitation	−.1102	−.0558	.0515	−.0599
	(2.6174)	(1.7110)	(.6406)	(2.4444)
South	−.1341	−.0637	.0268	−.0676
	(2.7047)	(2.5029)	(.3983)	(3.2233)
Interaction $a_n^i \cdot n^i/10^2$	−.0553	−.0614	−.1158	−.0554
	(3.1456)	(4.7680)	(4.0981)	(6.5405)
Actual Experience: $a_n^i/10$	.2782	.3373	.3920	.2764
	(3.2805)	(4.4035)	(1.1048)	(5.5906)
Potential Experience: $n^i/10$	.0418	.0044	−.0001	.0194
	(.6894)	(.0665)	(.0003)	(.4718)
Intercept				
Elementary school	−.0331			.1097
	(.1893)			(1.2020)
High School		.2680		.1044
		(3.3030)		(1.4646)
College			.3942	.2736
			(1.9563)	(3.1079)
β_{69}	.1941	.0973	.0721	.1334
	(5.211)	(3.211)	(0.832)	(5.8636)
β_{70}	.2651	.1614	.1783	.2027
	(7.061)	(5.433)	(2.129)	(4.1815)
β_{71}	.3716	.2399	.3328	.2974
	(9.778)	(8.192)	(4.014)	(6.3771)
β_{72}	.4759	.3404	.3530	.3924
	(12.208)	(11.706)	(4.366)	(8.1591)
β_{73}	.4172	.3887	.5343	.4328
	(7.632)	(12.397)	(6.050)	(8.0079)
β_{74}	.5133	.4514	.6665	.5125
	(8.725)	(13.026)	(6.951)	(9.1087)
R^2	.2227	.2434	.2899	.2487
ρ	.5613	.4708	.3224	[a]
σ^2	.3257	.2101	.2273	[a]
σ_μ^2	.1830	.0990	.0730	[a]
σ_ν^2	.1430	.1110	.1540	[a]
Number of observations	1448	2148	390	3986
Number of individuals	222	366	67	655

[a,b]See Table 1; t-statistics in parentheses.

additional variables are also included in the regressions to reflect: "native ability," as measured by the score on a short sentence test administered in 1972; "health limitations" affecting employment, as self-reported for each year; and residence in the South for each year. Each regression also includes a measure of potential experience, actual experience, and an interaction term.[8]

The regression results pooled across schooling groups indicate that the model explains about 25 percent of the variance in logarithmic wages for both black and white workers. The results in Tables 1 and 2 explain between 17 and 29 percent of the variance in *log* wages within race/schooling classes. The combined explanatory power of the stratified models for whites is 28 percent (20 percent from within schooling group regressions and 8 percent from stratification); for blacks the comparable figure is 26 percent (18 percent within group and 8 percent between groups).[9]

The estimates suggest that there are substantial returns to graduation for those with some high school or college training. The wages of white high school graduates are about 11 percent higher than those of otherwise comparable nongraduates; for blacks the estimate is 18 percent. The coefficients imply that the wages of white (black) college graduates are about 26 percent (16 percent) higher than those of college drop-outs; for those with postgraduate education, wages are higher by an additional 37 percent (64 percent).[10] The variable reflecting elementary school completion is insignificant; however, almost all workers in this schooling group have completed 6-8 years of education.

The other personal characteristics (ability test, health limitations, residence) have the expected signs. The ability measure, although quite crude, has a positive and generally significant effect on wages.[11] There is no discernible positive interaction between schooling and ability, contrary to the findings of John Hause. The difference in earnings associated with a movement from the lowest to the highest ability group ranges from 20 to 75 percent in the different subsamples. Health limitations depress the wages of individuals with a high school education or less by 3 to 11 percent. However, individuals with a college education, generally in less physically demanding occupations, apparently suffer little or no loss with health limitations. Individuals residing in the South tend to have lower wages except for the college educated. The decreasing importance of residence at higher schooling levels is consistent with the notion that labor markets are less regionalized for the more educated (see Hanushek, 1973). The wage difference associated with southern residence is greater for blacks than for whites.

The results indicate quite strongly the importance of actual experience and the interaction term in determining wages, but only for whites is the coefficient of potential

[8]The actual experience of each worker was computed from the answer to the question "How many years of labor force experience do you have?" asked in 1974. Actual experience in prior years was computed by subtracting the cumulative proportion of the years worked from the 1974 figure. For these calculations, full time is defined as 1750 hours/year (or 50 weeks of work at 35 hours/week). Some experimentation was done by defining full time as 1750, 2000, and 2500 hours per year with little effect on the estimates.

[9]An F-test rejects the hypothesis of equality of coefficients across schooling groups. These tests allow for intercept and schooling coefficient differences. For whites, $F_{26,11152}$ is 1.97; for blacks, $F_{26,3941}$ is 1.69. ($F(26, \infty) = 1.76$ at the .01 level.)

[10]Note that these are not pure "sheepskin" effects in either the pooled or stratified models. The estimated coefficient represents the returns for completion over the median noncompleter within the same schooling class. For example, the 11 percent return to white high school graduates represents the return to additional years above the median noncompleter in the 9-11 year group plus any sheepskin effect. In the pooled models, separate intercept terms are estimated for the schooling classes, giving the schooling coefficients an identical interpretation, i.e., a 12 percent return to high school graduation as compared to the median noncompleter in this schooling group.

[11]The ability measure is the score on a "short sentence" test. Scores can range between 0 and 13, and it appears that there might be a "topping out" problem in that many people achieve the maximum score. This may lead to the smaller estimated effect of ability for the college groups.

experience consistently significant.[12] (These coefficients are discussed below.)

For white workers, the estimate of ρ (the proportion of residual variation attributable to unmeasured characteristics of individuals, μ^i) suggests that more than half of the residual variation in earnings is individual-specific. For black workers, however, the estimate of ρ is smaller—significantly so for the college group. This arises from a larger transitory component and, perhaps, a smaller permanent component of the error variance for blacks.[13] This finding implies less stability in lifetime wages and earnings for blacks of a given schooling group relative to comparable whites.

It is worth emphasizing the overall results. For both black and white males within any schooling class, the theory of postschool investment explains roughly 25 percent of the variation in productivity; 45 percent is "explained" by other systematic (but unmeasured qualities) of individual workers (for example, their "motivation") or their work histories (for example, their "good luck"); and about 30 percent is completely unexplained.

III. Human Capital Interpretation

The estimates presented in Tables 1 and 2 are based upon a simple model of human capital investment, relating observed hourly wage rates to a linear profile of capital investment and their annual returns. The principal novelty in the analysis is the distinction between the actual labor market experience gained by individuals and the potential experience gained simply by aging. This permits direct estimation of the parameters of the postschool investment profile and the rate of return.[14] Table 3 displays the estimates of these parameters. Part (a) of the table arrays the rates of return to postschool capital investment for each of the six race/schooling groups for male workers. These range from 3.18 to 6.10 percent for wages (and 4.42 to 8.88 percent for earnings (not shown)). The rate of return measured in hourly wages is lower than that measured in terms of earnings, although the pattern of returns across races and schooling groups is generally consistent between wages and earnings. It also appears generally true that postschool investments

[12]Compared with the "conventional" specification, which includes potential experience and its square, the results reported explain between 2 and 9 percent more of the variance in *log* wages and earnings.

[13]A lower estimate of ρ in any stratification will arise from either a small σ^2_μ or a large σ^2_ν. Because 1,872 families (out of the 4,802 households in our panel begun in 1968) were selected from the Survey of Economic Opportunity (*SEO*) on the basis of low 1966 family incomes, the estimates of σ^2_μ and ρ could be biased by sample selection. (Of course, if low incomes in 1966 resulted from low transitory components, there would be no bias.) Since the sample of black workers includes a higher proportion of *SEO* families, σ^2_μ may be biased downwards relative to whites. However, σ^2_ν is so large that even if the true σ^2_μ for black workers were as large as the estimates for whites, ρ would still be 8 to 13 percent less for blacks than for whites. It should be noted that the estimation procedure is designed to hold constant any nonrandom factors causing otherwise identical workers to have different permanent incomes; hence any selectivity bias should not affect the estimated coefficients reported in the tables.

[14]Parts of our interpretation of these results would be altered if vintage of schooling also affects earnings (see Weiss and Lillard). Since vintage (school completion date) equals real time t minus potential experience n, the coefficient interpretation depends upon the particular specification of the vintage effects on wages or earnings. For example, if vintage produces parallel shifts in *log* wage profiles, then the rate of return r and the slope of the investment profile B in equation (11) are still identified, even though vintage effects are included in the estimated coefficients of n^i and the β's. This identification problem is clearly more important when aging and labor market experience are not separately measured, and has been resolved only by making extremely strong behavioral assumptions (see Weiss and Lillard and Finis Welch). Even when age and experience are separately measured, however, some identification problems remain unless additional information about the specification and measurement of "vintage" is introduced. In principle, several alternatives are possible. Vintage could be parameterized (say by measures of school quality) and incorporated directly into the estimation; or, if vintage could be assumed to cause parallel shifts, then the vintage parameter(s) would appear as an explicit component of the β's (for example, a linear trend in the special case of proportionate shifts) which could be estimated by auxilliary regression on the β's (given sufficient longitudinal information). Unfortunately, currently available data will not support these alternatives.

TABLE 3—ESTIMATED RATES OF RETURN TO POSTSCHOOL INVESTMENT AND IMPLIED INVESTMENT PROFILES

	Elementary School	High School	College	Pooled
(a) Rate of return: r				
Whites[a]	3.18	5.41	5.60	4.63
Blacks[a]	4.05	3.71	6.10	4.09
(b) Slope of investment function: B				
Whites	−.0483	−.0317	−.0414	−.0399
Blacks	−.0273	−.0331	−.0380	. .0271
(c) Intercept of investment function: A				
Whites	(−)	.1825	.3107	.1920
Blacks	1.0321	.1186	(−)	.4743

[a]Shown in percent.

yield higher returns for those with more formal education. In addition, there is some evidence that the marginal return to postschool investment is greater for black workers than for white workers.

It is important to note, however, that the rate of return calculated here is the amount that equates individual earnings along a given profile. Thus, it is a "growth adjusted" rate of return, and it is not the *ex post* rate of return that any individual actually received during the 1968–74 period. The return to postschooling investment (in nominal terms) would be found adding r and the β_t for each year.[15] In real terms, the part of the β_t's that represents price changes (see below) would be eliminated from this calculation.

The slopes of the investment profiles suggest that postschool investment declines at 53 to 140 hours per year, and there is some evidence that investment declines more rapidly for the more educated.[16] However, there is little apparent consistency in the estimates of the intercepts of the investment functions. The instability of these estimates may reflect the nonlinearities of the investment profile at entry into the labor force discerned by other studies (see Klevmarken and Quigley) or, alternatively, vintage effects that are not identified in the models (see fn. 14). Taken literally, the investment profiles imply rather short periods of net investment (for example, less than 6 years for white high school graduates).

[15]If the β's were the same across all groups, then ignoring dynamic factors in a cross-section estimation of the rate of return would not be a serious problem—the real growth rate could simply be added to the estimated rate of return. However, as shown below, it is not possible to assume equal growth rates across groups.

[16]Investment is measured in terms of time equivalents; thus, this is calculated by multiplying the slope of the investment profile times 1750 hours, the assumed full-time work year.

IV. The Determinants of Shifts in Profiles

Clearly, the actual returns received by individuals depend upon factors other than their human capital investment strategies, their abilities (even appropriately measured) and their health status. In the long run, they depend upon the amount, type, and quality of complementary capital, its productivity and organization, and other factors. In the short run, the returns received by workers depend upon the excess supplies of workers with particular skills and occupational characteristics.

During the recent period of inflation, recession, and recovery, there has been increasing concern about changes in relative earnings and short-run effects of macroeconomic conditions upon identifiable groups of workers (see Freeman). The β's presented in Tables 1 and 2 indicate that annual changes in profiles for each of the six groups of workers during the 1968–74

TABLE 4—REGRESSION COEFFICIENTS FOR THE RELATIONSHIP BETWEEN PERCENTAGE CHANGE IN THE WAGE PROFILE (β_i) AND EXOGENOUS FACTORS

Independent Variable	Linear	Logarithmic
CPI	.642[a]	.874
(1967 = 100)	(5.62)	(6.09)
Real *GNP*	.667[b]	.674
(in \$B)	(3.03)	(2.72)
Race	.066	.065
(1 = black)	(4.40)	(4.60)
High School	−.063	−.063
(1 = high school)	(−3.82)	(−4.03)
College	−0.61	−.061
(1 = college)	(−3.21)	(−3.43)
Constant	−1.272	−8.671
	(−8.64)	(−7.30)
R^2	.91	.91

Note: t-statistics in parentheses.
[a]times 10^2
[b]times 10^3

period vary significantly. In Table 4, we relate the pattern of these parallel shifts to aggregate economic conditions—as measured by the movements in real output and price levels. Also included are dummy variables for race and schooling groups.

Over 90 percent of the annual shifts in earnings profiles for these groups can be explained by the systematic influence of aggregate conditions (in either linear or logarithmic form) and the three dummy variables.[17] Price changes are not completely passed through into wages (or earnings, not shown). While the price coefficient in the logarithmic models is not significantly different from one, this does indicate potential biases in estimation where wages and earnings are simply deflated by the cost of living. The *GNP* coefficient indicates that a 1 percent increase in *GNP* is reflected in a .67 percent increase in wage profiles.

The results further suggest that—holding investment profiles and other individual characteristics constant—the high school and college groups both lost in relative terms over this period. The marginal returns of the college educated (relative to those who stopped at high school) remained virtually constant.[18] However, the limited time-series information makes it difficult to distinguish between secular changes in relative wages and more short-run phenomena.

Similarly, the position of blacks relative to whites appears to have improved during this period, other things equal. There is an important qualification, however: the racial differences in profiles indicate that the wages of black high school and college graduates would otherwise have fallen over the period, relative to white workers with the same pattern of labor market experience.

V. Conclusions

This paper extends the human capital model by considering the distinction between the actual labor market experience of individuals and their potential experience gained simply by aging. This distinction permits the underlying parameters of the capital investment function and the rates of return to schooling and postschool investment to be estimated directly.

The estimates of the investment model explaining both wages and earnings appear reasonably consistent with the human capital formulation. The implicit rates of return to postschool investment and the slopes of the underlying investment schedules seem plausible. "Growth adjusted" rates of return (those normalized for economic growth, price changes and short-run shifts in labor force demands) range between 3 and 9 percent. The investment profiles themselves (assumed to be linear) decline in a reasonable manner with a rate

[17]The models were estimated by generalized least squares using the 36 estimated β's from Tables 1 and 2. The *GLS* procedure (see Hanushek, 1974) allows for the fact that the β's are themselves regression estimates and thus contain some sampling variation.

[18]These estimates are not, however, directly comparable to Freeman's results, since he explicitly considers "twists" in the profiles (i.e., that the position of young college workers has worsened even though the position of all college workers may not have).

of decline that increases with level of schooling.

There is, however, some reason for caution in interpreting the human capital formulation of the wage and earnings models. First, the intercepts of the investment profile are not well estimated and, taken literally, imply implausibly short periods of positive net investment after leaving school. Second, estimation of different formulations of the same basic model (to explain wage growth as opposed to wage levels) did not yield plausible estimates of the underlying investment parameters.[19] While each of these problems could be explained by nonlinearities in the investment profile, they could also indicate more fundamental problems with the underlying investment model.

The intertemporal shifts in the earnings profiles are explained by *GNP* growth, price changes, and terms relating to specific race and schooling classes. Price changes were not completely passed through to wage changes, indicating potential problems from simply analyzing deflated wages. The elasticity of the profiles with respect to total output is about .67. Over the period 1968 through 1974, the relative wages of blacks has improved while the wages of high school and college educated individuals have fallen relative to those with less education. Differences between high school and college educated workers are insignificant.

[19]Investigation of an alternative specification of (11) produced results which were less consistent with the human capital model. The conceptual framework should, in addition to explaining the level of wages, also explain changes in wages over time. This latter formulation has the advantage that no assumption about the pattern of labor market experiences over a lifetime is required, since the growth in wages will be a function of total experience and the change in experience in two adjacent years. Models of this form did not yield plausible estimates of the investment profile or of the rate of return to postschool investment, perhaps because of problems from estimating wage rates, from the familiar increase in signal to noise in time-series models estimated on differences, or from the increased importance of the assumed linear investment profile. Alternatively, it could reflect more fundamental problems with the human capital model. It is not possible to distinguish among these possible causes.

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