EDUCATION AND THE NATIONAL WEALTH OF THE UNITED STATES*

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Human capital theory has motivated a great many empirical investigations into the relationship between education and earnings potential. These studies test refinements of the theory, but do not attempt to value education for the economy as a whole. This study develops series which track human wealth and its educational components for the United States from 1946 to 1980. Three related educational time sequences emerge: (1) schooling wealth, the present value of the current and future contributions of the existing schooling stock to national income; (2) net change in schooling wealth, the amount added to present value in that year; and (3) schooling investment, the present value of the future contributions of the new schooling conducted in that year.

One important lesson of this exercise is that the last two series can be quite different as a result of the pattern of appreciation and depreciation of human wealth over the lifetimes of individuals. Moreover, education increases the age of peak human wealth and thus should shorten the period during which individuals save for retirement. This phenomenon may induce a demographic cycle in the nation's savings rate, especially evidenced with the aging of the baby-boom cohort.

The magnitudes of the human and schooling wealth estimates are large when compared to financial wealth. For a 4 percent rate, the period-wide average for human wealth is five times—and schooling wealth 2.6 times—the Federal Reserve Board's measure of household net worth. These estimates are naturally sensitive to the discount rate chosen, but show that the gap between human and financial wealth has been widening and that the value of schooling provided in any year greatly exceeds its cost. Schooling represents a form of saving whose value is several times the conventional measure of saving.

1. INTRODUCTION

Intangible human wealth in the form of earning potential is the chief product of education. This view of education as investment has motivated many empirical investigations. With few exceptions, though, these studies test refinements of the theory rather than attempt to value education for the economy as a whole or to develop series which track educational wealth over time. This study generates such series by combining econometric techniques that measure the earnings effects of schooling with standard demographic methods.

Basic data series on wealth—in all forms—are central to macroeconomics and government finance. Studies of savings and investment behavior that ignore the human capital accounts are incomplete and may give incorrect conclusions. To be specific, since a sizable share of public expenditures is devoted to education, failure to account for human capital will distort any measurement of government's impact on capital formation. For example, the tests of Feldstein (1974, 1982) and others[1] use a very narrow definition of wealth to develop the proposition that

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[1]See for example Munnell (1974), Barro (1978), Darby (1979), and most recently the revision of Leimer and Lesnoy (1982). Louis Esposito (1978) provides a comprehensive review of the debate.

the Social Security System reduces the economy's rate of economic growth. By contrast, Pogue and Sgontz (1977) view education for the young and pensions for the old as parts of a grand social contract which on balance increases productive capacity. Education is a collective investment in the young by their elders whose ultimate payoff of higher productivity and wages is more than enough to finance the Social Security retirement benefits that return to the old.

Capital series that incorporate such intangibles as education have already been developed by John Kendrick (1976). His capital series are not intended to accurately measure the wealth of the economy, since to Kendrick wealth and capital are distinct concepts. An asset's worth is the present value of the returns it generates. On the other hand, to measure capital, acquisition cost is appropriate[2] since "estimating the present value of future income streams through discounting... involves circularity when the capital estimates are used as a base for estimating rates of return, or productivity" (p. 18). For education that is financed through the public sector no appeal to profit maximization can be made to argue for the equality of acquisition cost with the present value of returns.

Several studies have attempted to value the aggregate benefits of schooling to the U.S. economy by looking at school enrollments and age-earnings profiles for each schooling level. Hines *et al.* (1970) use the One-in-One-Thousand Sample of the 1960 Census of Population to derive the benefits from schooling in the 1959–60 academic year. They assume that for all age groups the difference in earnings between two adjacent schooling levels observed in the 1960 cross section does not change with time.[3] Their procedure suffers from its inability to control for important demographic variation and, hence, to separate the influence of education from other factors. More generally, cross sectional analysis is not an appropriate means to impute the determinants of lifetime earnings in a world that is not in a demographic steady state. Similarly, the use of purely cross sectional methods casts doubt on the Commerce Department's Current Population Report on "Lifetime Earnings Estimates for Men and Women in the United States: 1979." [4]

In this study we estimate age-earnings profiles from pooled cross-section time-series data. This allows us to disentangle the effects of secular growth in the economy from the wage premium that is paid for experience. The paper proceeds in three steps. In section 2 we estimate the contribution of schooling to lifetime earnings for each of four race-sex groups. Section 3 explains our methods of calculating the economy's physical stock of schooling and of using the earnings equation to value this stock. Section 4 presents the resulting wealth and investment series.

[2]In the case of schooling, this essentially is the economy's cost of operating its schools plus the opportunity cost of the time of students.

[3]Actually Hines *et al.* compute the social rate of return to education by combining benefits and *costs* of 1959–60 schooling in a calculation of internal rate of return. The same technique is applied to the 1970 Census of Population by Albert Niemi (1975).

[4]Recent work by Jorgenson and Pachon (1981) improves on these measures somewhat by using methods that account for economic growth to measure lifetime labor incomes.

2. The Contribution of Formal Schooling to Life-Cycle Earnings

An individual's human capital is defined conventionally as the discounted sum of his potential stream of life-time earnings. A large share of public investment—by most accounts the largest—is government's contribution to the stock of human capital. The magnitude of that contribution can be understood in large part by the relationship between schooling and life-time earning streams for broad classes of individuals in the work force.

Prior efforts to explore the determinants of earnings have concentrated on isolating schooling effects from other influences. They deliver three caveats: (1) education effects are not easily distinguished from correlated characteristics such as innate ability and family background; (2) selection biases cloud the interpretation of measured returns to education; and (3) human capital, like physical capital, is characterized by vintages which often can be confused with experience. These pitfalls raise serious questions about appropriate econometric methods for measuring the value of education.

If an individual's background and intelligence are left out of the analysis, positive correlation between these traits and education will result in an upward bias in the estimated return to education. Paul Taubman (1976a) in his studies of twins finds that failure to control for genetic differences and family background can bias the schooling effect by as much as 62 percent, depending on the assumptions made on the size of schooling measurement error relative to its sample variance.[5] For this study the limitations of the data do not allow any control for innate ability, but the Taubman result places bounds on the pure education effect.

A second related problem, selectivity bias, arises from omitting motivation and, again, may generate over-estimates of the effects of schooling. To give two examples, a high school graduate's earnings provide estimates of the earnings that the college graduate would have with only a high school degree, and a labor force participant's wage provides an estimate of the opportunity cost of nonparticipation for those out of the labor force. These observed differences may be the result of self selection on the basis of individual characteristics we cannot observe. Methodologies for dealing with these problems are discussed by Heckman (1974) and Hausman and Wise (1977) and have been applied to education by Willis and Rosen (1979). Again these techniques are not directly applicable to our study but can guide the interpretation of the results.

Finally, the need to distinguish vintage from experience leads to serious problems when cross-section data are used to estimate lifetime earnings of individuals born at different dates. A number of key factors that influence earnings do not vary in cross-section. Among them are secular changes in the pattern of wages over time and educational vintage. Sherwin Rosen (1976) demonstrates the parallels between vintages of human capital and physical capital. Indeed, the composition of the human capital stock has changed dramatically. The labor force

[5]Zvi Griliches (1979) notes that as the ratio of measurement error to variance increases the bias falls toward zero. This tendency is weakened somewhat by the proviso that measurement error not be correlated with innate ability or family background. But, in fact, measurement error in the sense of variation in the quality of schooling *is* likely to be correlated with family background, even if not with innate ability.

contributions of women and minority group members are changing, as are the sizes of birth cohorts, bringing increased competition to white males. Moreover, as Richard Freeman demonstrates (1976), the business cycle has effects on earnings that cannot be captured in cross-sectional analyses. Since education changes the way an individual's earnings vary with the cycle, cross-sectional analyses again suffer. Only by pooling cross section with time series can the effects of worker vintage, cohort education, and other secular trends be disentangled from the influences of experience.

2.1. *Data*

The ideal data set for our investigation would provide complete earnings histories of a broad range of cohorts. It would provide all demographic characteristics salient for earnings differentials: race, sex, age, work experience, schooling, birth cohort, employment status, and proportion of the year worked. All potential sources are incomplete in some important way. The data source best suited to our needs is the 1973 Current Population Survey (CPS)-Social Security Administration (SSA)-Internal Revenue Service (IRS) Exact Match Sample.

Finis Welch (1979) used successive public use surveys from the CPS. These are not available for years before 1967. An attractive source of data would seem to be a panel such as the Panel on Income Dynamics or the National Longitudinal Surveys. But existing panel data are neither representative of the broad population of potential earners, nor sufficiently long running to assess vintage shifts in earnings patterns and the evolving effect of schooling. The Social Security file by itself does contain annual observations of earnings of individuals since 1951, but the demographic data are scant and lack, specifically, information on schooling.

By matching the Social Security file with the 1973 CPS and with IRS files, the Exact Match Sample effectively creates a broad panel survey at very low cost per observation.[6] The Exact Match Sample contains extensive socio-economic and demographic information (316 variables) on 90,175 individuals aged 14 and above, a one-in-1,500 sample of the United States civilian population. Most of the important descriptive information is from the 1973 CPS March interview reports. The SSA records contribute annual earnings from 1951 to 1976 along with the corresponding number of Social Security quarters of coverage (to control for part year employment). Of course, the advantages of a true panel are not present because the demographics are not updated each year. But the variables we use do not have this defect.

The SSA earnings data do have three serious shortcomings for this investigation: (1) not every worker is covered under the Social Security System; (2) for those who are covered, the earnings history spans only 1951 to 1976; and (3) the earnings are truncated from above by the maximum tax base in each year. The first defect is less of a problem today since more than 90 percent of workers are covered, but in the early 1950s, even after the major reforms of 1950 expanded the system, coverage was closer to 60 percent. In these years there is a non-negligible probability that an annual earnings record is incomplete because the person moved between covered and uncovered employment. The second defect

[6] A description of the methodology used to create this data set is presented by Scheuren *et al.* (1980).

means that we can observe at best a 26 year portion of an individual's career. But out of the standard work life-span of 46 years we have, after all, more than half of the years and a good deal more than the available panels.

The third defect is the most serious. Earnings beyond the maximum taxable base in any given year are simply not recorded. The problem is greatest for males, as would be expected, especially for white males where 45 percent of all observations on earnings are at the tax base limit. Under these circumstances ordinary least squares yields biased results. Taubman and Rosen (1982) show the extent of the bias for white males and how to overcome it. At the same time, they demonstrate the value of the Exact Match Sample in disentangling the influences of secular trends and experience. Our use of this sample closely parallels theirs.

2.2. *Methodology*

Lifetime earnings profiles for each of four race-sex categories—white male, nonwhite male, white female, and nonwhite female—are estimated with a standard earnings equation derived from Mincer (1974). In its simplest form, Mincer's model equilibrates an (infinitely lived) individual's expected rate of return for education with the discount rate, hence generating a linear relationship between the natural logarithm of annual earnings and years of schooling; adding experience in quadratic form allows for a concave earnings profile. Our model, in addition, accommodates vintage effects by including cohort information and part-year participation by including the number of Social Security quarters worked.

In most ways our specification follows Taubman and Rosen (1982). We diverge by limiting the number of regressors to the information we possess on the population at large. The omission of demographic variables such as region, veteran status, and marital status does not significantly affect the estimated coefficients for education, experience, and the birth cohort. Further, rather than controlling for birth cohort with dummy variables, we include a continuous birth year variable in quadratic form.

We construct and analyze two sets of data for each of the four race-sex categories. The first data set is the standard cross-section drawn from person records of 1972. The second data set is a conversion of the person records from the Exact Match sample into a pooled cross-section time series of individual earnings histories. Its features are summarized in Table 1. By extracting a ten percent random sample of white records sample sizes have been made roughly equal across races.

The most satisfying way of handling the truncation problem under the circumstances is James Tobin's (1958) probit analysis for limit observations, tobit. Using the maximum taxable base as the known mass point in the tobit regression, the model can be estimated for all observations combined under the assumption that earnings are distributed lognormally. This procedure is flexible in allowing the mass point to vary across observations (actually, across years), and hence makes efficient use of all available information in producing estimates that are reasonably robust.[7]

[7]William Green (1981) has devised a simple linear method for correcting OLS bias when analyzing limit observations, but it is restricted to cases with a fixed truncation level for all observations in the sample.

TABLE 1

SUMMARY STATISTICS ON POOLED TIME SERIES AND CROSS SECTION FROM THE MATCH FILE (STANDARD DEVIATIONS IN PARENTHESIS)

	White Males	Nonwhite Males	White Females	Nonwhite Females
Sample size	28,653	24,074	26,732	29,240
Reported earnings (1967 dollars)	4,647	3,674	2,668	2,253
	(2,228)	(2,310)	(1960)	(1932)
Time worked (quarters)	3.71	3.51	3.23	3.15
	(0.76)	(0.97)	(1.16)	(1.20)
Experience (years)	20.84	20.80	19.56	19.74
	(13.72)	(13.87)	(13.86)	(13.43)
Schooling (years)	12.54	10.60	12.55	11.48
	(3.31)	(3.84)	(2.70)	(3.36)
High school (percent)	0.65	0.40	0.68	0.50
College (percent)	0.16	0.07	0.10	0.08
Cohorts (percent)				
1880-1900	0.034	0.036	0.041	0.028
1901-1905	0.045	0.043	0.041	0.032
1906-1910	0.079	0.075	0.052	0.058
1911-1915	0.087	0.079	0.073	0.075
1916-1920	0.112	0.084	0.115	0.086
1921-1925	0.113	0.111	0.103	0.105
1926-1930	0.132	0.118	0.124	0.122
1931-1935	0.112	0.117	0.108	0.118
1936-1940	0.094	0.103	0.090	0.104
1941-1945	0.082	0.091	0.094	0.114
1945-1950	0.066	0.082	0.093	0.091
1951-1959	0.044	0.061	0.066	0.067

2.3. *Specification and Results*

In all model specifications, consistent with Mincer's formulation, the dependent variable is the log of real earnings (deflated by the CPI). The core regressors are log of quarters worked, years of schooling, years of experience, birth year (counting from 1880), and the squares of the last two variables. The time series analysis, spanning 1951 to 1976, includes the unemployment rate to control for the state of the economy. Experience is calculated from the difference between age and number of years of schooling plus 5 (to account for preschool years), but with a twist: no experience can accrue before age 14. Quarters worked measures one dimension of labor force participation, the fraction of the year an individual holds a job.[8]

Schooling is specified with a linear spline with knots at the entry to high school and to college. The coefficient for high school should be understood as the difference between the earnings effects of the high school years and prior (base) schooling years. Similarly, the college effect is the increment over high school. Hence, the t-statistics are direct tests of the validity of allowing for these

[8]Prior to 1978, the typical worker is credited by the Social Security Administration with a quarter of coverage for each calendar quarter in which he was paid $50 or more in wages for employment covered under the law. Rules differ slightly for agricultural workers and the self-employed. The definitions change in 1978, but this does not trouble us since the Exact Match File ends in 1976. See the *Social Security Handbook* (1978).

differences. In the final refinement of the pooled regression, three interaction terms are added—birth year × schooling, birth year × experience, and experience × schooling—to account for vintage effects and the variation in the contribution of schooling to earnings across birth cohorts. These interaction terms, especially the birth year-schooling interaction, have much explanatory power, and, as the ensuing tables show, they change considerably the simple schooling and experience coefficients.

A major issue in the model specification is how to best represent birth cohort effects. We test the validity of substituting for the eleven cohort dummies used by Taubman and Rosen (see Table 1) a simple birth year variable in linear and in quadratic forms. The proposed variable is (birth year − 1880)/10. A simple F-test is not strictly appropriate, since this substitution is not a simple set of linear restrictions on the dummy coefficients. But an "appropriate" likelihood ratio test can be constructed.

The unrestricted model (including the eleven cohort dummies) is

$$\ln E = \sum_j \beta_j X_j + \sum_{k=1}^{11} \delta_k D_k + U, \tag{1}$$

where $\ln E$ is the log of annual earnings, the D_k's are the birth cohort dummy variables, and the X_j's are the other demographic characteristics of the model. A set of restrictions on the dummy coefficients akin to replacing the dummies with the birth year variable is

$$\delta_k = k\delta_1, \qquad k = 2, 3, \ldots, 11.$$

The restricted model then becomes

$$\ln E = \sum_j \beta_j X_j + \delta_1 \left(\sum_{k=1}^{11} kD_k \right), \tag{2}$$

which is equivalent to constraining the birth year effect to be uniform from cohort to cohort. The $\sum kD_k$ variable is a "stepped" version (in 5-year increments) of the annual birth year variable. Hence, replacing the eleven dummies with a linear birth year variable is a close approximation to equation (2). The F statistic that emerges from the likelihood ratio comparing equation (2) with (1) is presented in Table 2, along with the performance of key regressors. The restriction is rejected at 1 percent significance, but not at 0.1 percent, which is arguably the more appropriate test given the large sample size. Extending this procedure somewhat by introducing a quadratic term in the cohort specification improves the model fit considerably. The implicit "pseudo" F-test on this weaker restriction is not significant at 1 percent. Hence, we claim that this last specification is best. The main advantage of this model is that it easily accommodates the interaction effects of the key regressors.

Table 3 presents the final tobit estimates and (for white males) focuses on three alternative models.[9] The comparisons for white males exemplify similar results for the other categories and highlight the advantages of using a time-series cross section.

[9]Not shown are the parallel ordinary least squares regressions which underestimate the schooling coefficients by as much as 50 percent, a corroboration of Taubman and Rosen (1982).

TABLE 2

SPECIFICATION SEARCH ON VINTAGE EFFECTS USING POOLED DATA

	White Males	Nonwhite Males	White Females	Nonwhite Females
Cohort dummies				
Mean effect	0.148	0.122	0.094	0.091
Schooling	0.067	0.078	0.056	0.097
Experience	0.073	0.071	0.015	0.045
Residual variance	0.5626	0.5550	0.6069	0.6453
Degrees of freedom	27,186	22,226	24,265	26,471
Linear specification				
Birth year	0.154	0.117	0.084	0.098
Schooling	0.069	0.076	0.060	0.095
Experience	0.074	0.070	0.019	0.051
Residual variance	0.5662	0.5597	0.6115	0.6501
Degrees of freedom	27,196	22,236	24,275	26,481
F Statistic	9.72	10.45	11.16	12.41
Quadratic specification				
Birth year	0.135	0.007	0.101	0.058
Birth year squared	0.003	0.022	−0.0034	0.019
Schooling	0.068	0.081	0.061	0.112
Experience	0.076	0.077	0.022	0.055
Residual variance	0.5638	0.5566	0.6082	0.6468
Degrees of freedom	27,195	22,235	24,274	26,480
F Statistic	1.81	1.98	1.75	2.16

TABLE 3

EARNINGS FUNCTIONS.
TOBIT SPLINES

	1972 Earnings	1951–76 Earnings				
	White Male	White Male	White Male	Nonwhite Male	White Female	Nonwhite Female
Constant	4.075	3.594	6.403	4.523	5.822	6.657
Quarters	2.023	2.065	2.063	2.011	1.931	1.776
Schooling	0.051	0.054	−0.049	0.033	−0.063	−0.136
High school	0.038	0.014	0.007*	0.007*	0.045	0.092
College	0.011*	0.005*	0.000*	−0.009*	0.041	0.059
Experience	0.009*	0.076	0.0132	0.054	−0.016	−0.032
Experience 2	−0.000*	−0.0011	−0.0007	−0.0008	−0.0001*	−0.0001*
Birthyear	0.082	0.135	−0.559	−0.346	−0.158	−0.557
Birthyear 2	−0.0015	0.003*	0.034	0.035	0.006*	0.042
Unemployment	—	−0.024	−0.030	−0.029	−0.009	0.004*
BY × School	—	—	0.021	0.012	0.004	0.017
BY × Exper	—	—	0.008	0.006	−0.002	0.008
Exp × Schl	—	—	0.001	−0.0008	0.0014	0.002
SER	0.7756	0.7513	0.7466	0.7383	0.7787	0.8018
Log likelihood	−586	−5,117	−4,993	−4,288	−3,352	−3,815
Sample size	3,966	27,205		22,245	24,284	26,490
% Limit obs.	43.4	47.2		21.2	6.9	4.3

*Asterisk signifies that the coefficient is not significant at 1%.

As expected, the cross-sectional data cannot distinguish the effects of work experience from the vintage of the labor. The experience variables are statistically insignificant (at 1 percent) for the 1972 cross section not only for the white males shown in the first column of Table 3 but also for the other three categories (not shown). Moreover, the birth year effect is consistently small. By contrast, the pooled analyses reveal important effects for experience. The second column shows that the initial year of experience raises a white male's earnings 7.6 percent. The birth year effect is at least twice as great in the pooled analysis as in the 1972 cross-section. Such discrepancies are not surprising. Experience and vintage vary independently in the pooled sample but not in the cross-section. The third column underscores the value of the three interaction terms: birth year × schooling, birth year × experience, and experience × schooling. The introduction of these terms not only improves the fit of the model, but seriously alters the simple linear effects, especially for schooling and vintage (birth year). All three of these variables are statistically significant in all four race-sex categories.[10]

Table 3 highlights, as well, for race and sex, differences in the contributions of schooling, experience, and vintage to lifetime earnings. The effects of vintage and experience are substantially greater for men than for women. This result supports previous work on sex differences by, among others, Niemi (1975). The vintage effect is about 50 percent higher for whites than nonwhites for both sexes. The influence of experience is almost the same among men of both race groups, but the experience effect is about three times as great for nonwhite women as for white women. This discrepancy may be due almost entirely to an imprecise measure of experience, i.e. rather than actual job experience, "potential" experience as measured by the difference between age and years of schooling.

Comparison of schooling effects is complicated by the spline specification and by the loss of experience that accompanies education beyond eighth grade. The top part of Table 4 shows the relative contributions to lifetime earnings of three selected levels of education, controlling for vintage.[11] The entries are proportional increases over the no-education base within each race-sex category. For example, a white male high school graduate earns 84 percent more than an uneducated white male, whereas a high school educated white female earns only 46 percent more than her uneducated counterpart. This discrepancy narrows at the college level. Among nonwhites the relative contribution of schooling is again greater for men through high school, but nonwhite women get a bigger boost from college than do nonwhite men.[12]

[10]The validity of using these estimates to measure the contribution of schooling to national wealth is called into question by the "signaling" controversy. Michael Spence (1974) provides comprehensive treatment of the problem. If schooling is just a vehicle for allocating scarce and desirable jobs the individual benefit from schooling cannot be aggregated. We have devised a way to test this proposition with our data set and report elsewhere that signalling is, indeed, secondary to training. See Kroch and Sjoblom (1986).

[11]Controlling for vintage means that every additional year of schooling beyond eighth grade must reduce experience by one year. Because of the quadratic form for experience, we must choose an age: 40 in this case, which means 26 years experience since eighth grade, 22 since high school., and 18 since college.

[12]The reader is reminded that the table gives incremental proportions based on the level of earnings of each group at zero schooling. No comparison of absolute earning capacity can be made from these figures. Indeed the base earnings of white men are more than large enough to offset the relatively large college effect for nonwhite women.

TABLE 4
THE INFLUENCE OF SCHOOLING ON LIFETIME EARNINGS*
(IN PROPORTION ABOVE THE BASE)

	White Male	Nonwhite Male	White Female	Nonwhite Female
Eight years	0.54	0.48	0.18	0.21
High school	0.84	0.82	0.46	0.74
College	1.17	1.17	1.03	1.68
	Marginal Contribution of a Year of High School			
Birth Year				
1900	0.022	0.028	0.024	0.026
1910	0.035	0.034	0.030	0.035
1920	0.048	0.040	0.036	0.044
1930	0.061	0.046	0.042	0.053
1940	0.074	0.052	0.048	0.062
1950	0.087	0.058	0.054	0.071
Mean effect	0.068	0.050	0.041	0.057

*Includes the negative effect of an additional year's schooling beyond eighth grade on experience.

The bottom of Table 4 illustrates how incorporating the birth year-schooling interaction causes the effect of schooling on earnings to increase toward younger cohorts.[13] This variation is greatest for white males, but is substantial in the other three categories as well, ranging from one half of a percentage point per decade for nonwhite males and white females to a full point for nonwhite females. This last observation implies that young nonwhite women benefit considerably more from formal schooling than their older counterparts, not so much because of large benefits to today's generation, but because older generations have typically benefited little from schooling. The weakest effect predictably shows up for white women.

3. CALCULATING THE VALUE OF THE ECONOMY'S STOCK OF SCHOOLING

Computing the value of schooling stock for the U.S. generates three related measures: (1) schooling wealth, the present value of the current and future contributions of the existing schooling stock to national income; (2) net change in schooling wealth, the amount added to present value in that year; and (3) schooling investment, the present value of the future contributions of the new schooling conducted in that year. To calculate a broader measure, human wealth, we add to schooling wealth the value of the unimproved body.

The stock of schooling for a particular year is contained in a matrix whose three dimensions are age, grade in school, and race-sex type. The cells hold the number of individuals alive in each class. With four race-sex categories, 18 grades of school,[14] and 65 ages this schooling stock matrix has 4,680 cells. The decennial

[13]Once again it is necessary to account for the effect of additional schooling on experience for each cohort. This is done by computing the first derivative of the earnings equation with respect to schooling years, noting that the derivative of experience with respect to schooling is negative.

[14]Grade 0, no schooling, is one of the grades included.

census provides the data to assemble the matrices for the years 1950, 1960, 1970, and 1980.[15] Interpolation gives stocks for the intervening years.[16] The year to year change in the stock of schooling can be traced to death, aging, and new schooling. We estimate the schooling stock for the nine years preceding and the nine years following the census using death rates from *Vital Statistics* and age and grade specific enrollment rates from that census. The final school stock matrix for each year is the weighted average of the stocks projected from the two nearest census years.[17]

School enrollment for each year from 1946 to 1979 derives from these annual schooling stock matrices. Assuming that all schooling takes place by the age of 30, school enrollment is the change remaining after accounting for death and aging.[18]

The estimated earnings equations are used to place values on the schooling stocks and school enrollments. The arguments to the earnings equations are schooling, age, birth year, the unemployment rate, and quarters worked. The first three are implicit in the schooling stock matrices. The unemployment rate is set to 5.25 percent, a value close to the nominal rate for the period 1946 to 1980. Social Security quarters covered gives a measure of the labor force participation for the period. These equations give the value of earnings of labor force participants between the ages of 14 and 65. Because our regressions will not predict well the earnings of individuals beyond age 65, we make the simple and extreme assumption that all individuals retire at that age.

A multinomial logit model for each race and sex is used to estimate the odds of working one, two, three, or four Social Security quarters in a year. The regressors are birth year, birth year squared, age, age squared, and the unemployment rate.[19] The results are presented in Table 5. To get probabilities on quarters for all employment, rather than just employment covered by Social Security, we reduce the probability for zero quarters by the fraction of individuals not covered by Social Security who actually work. We then increase the other probabilities proportionally. These probabilities are used with the earnings equations to generate expected earnings.[20]

[15]For each of the census years we combine information from several published tables in constructing this matrix. A detailed description of our calculations for 1960 appears in Kroch and Sjoblom (1984).

[16]The Census Bureau's Current Population Survey does collect educational data annually, but public use samples are not available for years prior to 1967 and the published summary tables do not provide sufficient detail.

[17]For 1946-49 the 1950 estimates get full weight.

[18]For ages greater than 30, the annual change in the schooling stock matrices is the sum of only two components, aging and death. From our stock matrices we could impute death rates which, in general, would differ from those reported in *Vital Statistics.*

[19]The data are from the Exact Match sample, but unlike the earnings equations data, they include observations with zero earnings or quarters.

[20]One could argue that those individuals who do not participate in the wage-labor force are gainfully employed at home. Measures of human wealth should not ignore the value of these activities. (This approach is used by Jorgenson and Pachon (1981), although with an extremely broad concept of nonmarket activity.) Assuming that (at the relevant margins) the values of nonmarket labor activities are equivalent to their counterparts in the wage-labor force, our earnings equations evaluated at four quarters predict the broadly defined earnings of every individual. In Kroch and Sjoblom (1984) we present alternate data series calculated on this basis.

TABLE 5

PREDICTING LABOR FORCE PARTICIPATION
MULTINOMIAL LOGIT ON SOCIAL SECURITY QUARTERS
ODDS RELATIVE TO THE ZERO QUARTER BENCHMARK

Quarters (sample frequency)	Constant	Birth year	$\left(\frac{\text{Birth}}{\text{year}}\right)^2$	Age	$(\text{Age}/10)^2$	Unemployment Rate
			White Males—36,689 observations			
0 (0.19)						
1 (0.02)	−0.413*	−0.576	0.097	−0.070	0.074	0.051*
2 (0.03)	−0.694*	−0.611	0.124	−0.047	0.058	−0.034*
3 (0.05)	−0.792*	−0.505	0.104	−0.032	0.042	−0.006*
4 (0.71)	−4.135	−0.425	0.104	0.258	−0.281	−0.024
					[−2 log likelihood ratio = 2,779]	
			Nonwhite males—34,449 observations			
0 (0.28)						
1 (0.04)	−1.049	−0.340	0.058	−0.036	0.032*	0.027*
2 (0.05)	−0.194*	−0.574	0.088	−0.031	0.019*	−0.017*
3 (0.07)	−1.329	−0.648	0.105	0.051	−0.066	−0.073
4 (0.56)	−3.909	−0.136	0.062	0.201	−0.213	−0.071
					[−2 log likelihood ratio = 1,985]	
			White Females—34,581 observations			
0 (0.55)						
1 (0.05)	−1.633	−0.078*	0.034	−0.038	0.027*	−0.049
2 (0.05)	−1.724	−0.037*	0.038	−0.065	0.062	0.009*
3 (0.05)	−1.899	−0.043*	0.037	−0.042	0.041	−0.044
4 (0.30)	−2.902	0.233	0.006*	0.041	−0.028	0.006*
					[−2 log likelihood ratio = 1,539]	
			Nonwhite Females—39,706 observations			
0 (0.53)						
1 (0.05)	−2.386	−0.324	0.072	0.018*	−0.027*	−0.072
2 (0.06)	−2.339	−0.479	0.086	0.057	−0.078	−0.114
3 (0.06)	−2.971	−0.600	0.103	0.093	−0.107	−0.111
4 (0.30)	−6.072	−0.350	0.095	0.229	−0.223	−0.032
					[−2 log likelihood ratio = 2,609]	

*Asterisk signifies that the coefficient is not significant at 1%.

The current return to a grade of schooling is the difference between an individual's predicted earnings with that grade of schooling and his predicted earnings with one less grade. The return to grade zero is the earnings predicted with no education. The present value of a grade of schooling to an individual in a given year is the discounted sum through age 65 of the current returns. The discount factors applied combine both a standard rate of interest and a probability of death.[21]

Taking the schooling stock matrix for a given year, multiplying each cell by the appropriate present value and then summing all of the resulting numbers gives *human wealth* in that year. Eliminating the grade 0 cells from this calculation gives *schooling wealth* for that year. Taking the school enrollment matrix for the year, multiplying each cell by the appropriate present value and summing gives *current schooling investment.*

[21]For the years 1946–78 actual death rates are used. For years beyond 1978 we use predicted death rates calculated by the Social Security Administration's methods.

4. HUMAN WEALTH AND SCHOOLING WEALTH

The human and schooling wealth series are aggregates that depend on the rate of discount and the population composition with respect to age, race, sex and education. Figure 1 illustrates the effect of the last three factors on the human wealth of average individuals of age 30 in 1967. The slopes of these curves represent the marginal value of the specific grades. The spline specification of the earnings equation is visible in the kinks at grades 8 and 13.[22] For all levels of education, white males are wealthier than nonwhite males, who are wealthier than white females. These rankings result from the higher wages of white than nonwhite males, and the lower labor force participation rates of white than nonwhite females. Not only is white male wealth greatest for every level of schooling, but the incremental value of a single year's schooling is generally greater. An exception is higher educated nonwhite females who, even with lower participation rates, get more value from college than do white males. (They get twice the value that nonwhite males do.)

Human wealth changes as an individual ages. The individual's human wealth is the sum of his discounted future earnings. When the individual ages one year the first term is dropped from the sum and all remaining terms appreciate at the

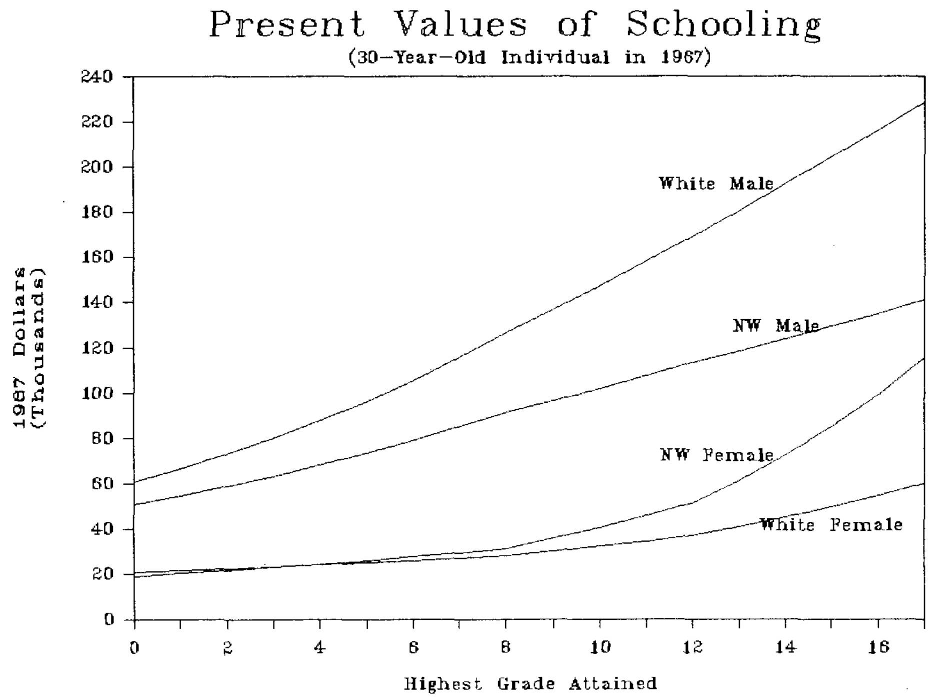

Figure 1

[22]The kink at grade 8 also reflects the way in which we measure experience. Attendance at grade 8 or lower does not require that an individual forego a year of experience while attendance at higher grades does.

rate of interest. The first change decreases wealth; the second increases it. Since, as our earnings equations show, undiscounted earnings increase with age, the second change can outweigh the first. Human wealth tends to appreciate in the individual's early years. The greater is the rate of discount, the more pronounced is this effect.[23] Figure 2 traces as a function of age human wealth of a college-educated white male born in 1930 for five rates of discount. In all five cases wealth increases at early ages. As the discount rate increases, not only does wealth at each age decline, but the age of peak wealth increases (from 32 at 2 percent to 46 at 10 percent). This pattern of appreciation and depreciation may influence the accumulation of other forms of wealth by the individual. Arguably, there is little need to begin amassing financial assets for retirement until after the date of peak human wealth. After this date, conventionally measured income includes a return of principal. Failure to consume this portion of income does not constitute a true act of net saving. The individual has simply shifted his portfolio of assets.

Educational attainment affects this pattern of appreciation and depreciation. Figure 3 depicts these effects at a 4 percent discount rate for a white male born in 1930. Not only does wealth at every age increase with education, but the age of peak wealth increases as well. This pattern reflects the positive interaction between experience and education in our earnings equation. The accumulation

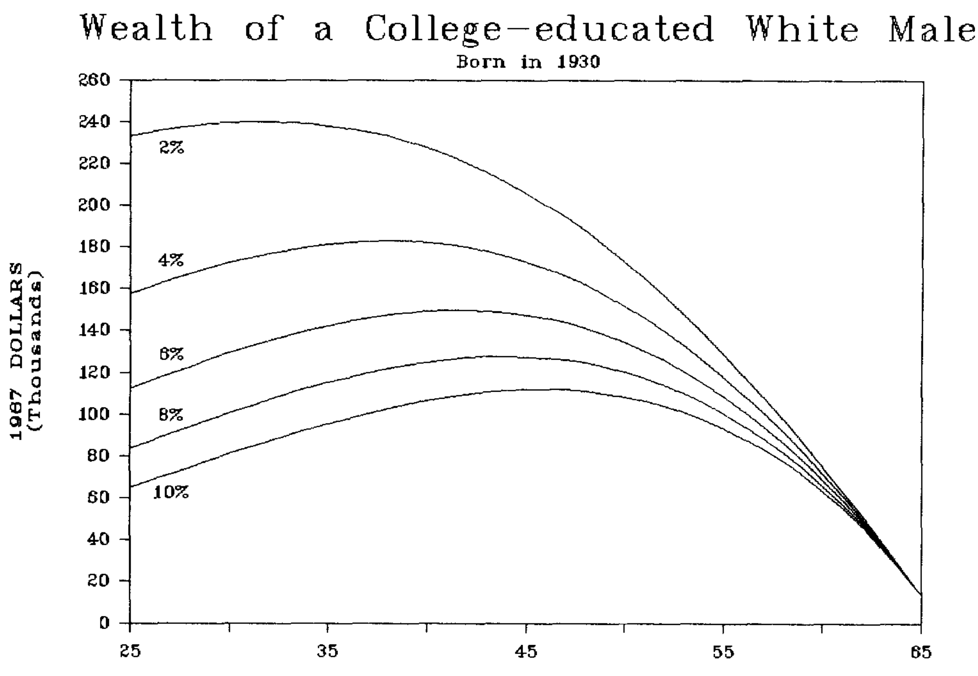

Figure 2

[23]Consider the consol with the same value as the individual's human wealth. Since the individual's earnings increase with age, in early years this consol may pay more than the individual earns. If so, human wealth must be increasing with age.

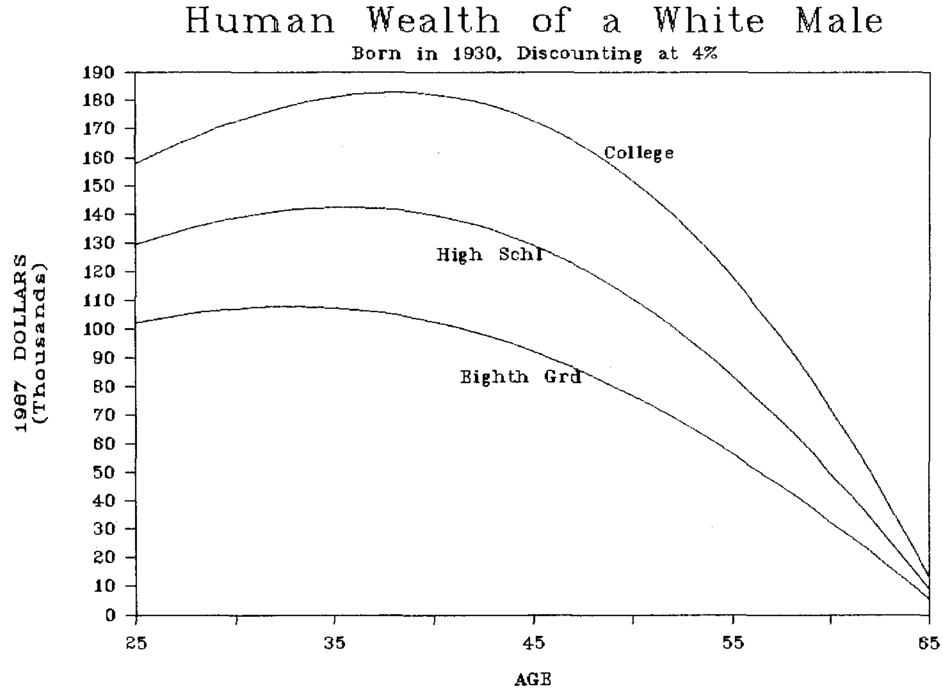

Figure 3

of schooling wealth does not stop at graduation. An individual obtains the seeds of this wealth in the classroom. Its value grows through the early years of the individual's working life. At the peak, appreciation may represent the bulk of the wealth.

Table 6 presents our human and schooling wealth series at a 4 percent discount rate. It also reports the annual increases in wealth as well as the value of each year's schooling investment. For comparison, Table 7 presents the same series for a 10 percent discount rate.

At a 4 percent discount rate the annual increase in the value of the schooling stock exceeds the year's schooling investment by roughly 25 percent. The appreciation of the already existing stock contributes the difference. Because the rate of population growth is sufficiently great, the appreciation experienced by individuals below the age of peak schooling wealth in the aggregate exceeds the depreciation experienced by older individuals. At a 10 percent discount rate the effect is stronger and appreciation is one half of the annual change.[24]

Our estimates of schooling wealth can be compared with the capital series on education and training developed by John W. Kendrick (1976). His education and training category is a bit broader than our schooling, but schooling is its major component. Equally instructive is the comparison between our total human wealth series and the Federal Reserve's household net worth. Figure 4 facilitates these two comparisons by plotting all four series: our total *human* wealth,

[24]Only with a 1 percent discount rate does schooling wealth, on net, depreciate.

TABLE 6

AGGREGATE VALUES FOR HUMAN WEALTH, 1946-80, IN BILLIONS OF 1967 DOLLARS, DISCOUNTING AT 4%

Year	Stocks: Human	Stocks: Schooling	Net Change: Human	Net Change: Schooling	Current Schooling Investment
1946	4,636.9	1,445.7	116.5	93.5	70.6
1947	4,753.4	1,539.3	134.1	102.7	79.2
1948	4,887.5	1,642.0	143.3	111.1	86.4
1949	5,030.9	1,753.1	147.4	114.8	89.7
1950	5,178.3	1,867.9	172.5	129.2	98.8
1951	5,350.8	1,997.1	202.9	135.5	104.0
1952	5,553.7	2,132.6	214.1	143.1	109.6
1953	5,767.8	2,275.7	221.7	152.6	117.5
1954	5,989.5	2,428.3	234.0	164.1	127.1
1955	6,223.5	2,592.3	268.8	180.2	138.2
1956	6,492.3	2,772.5	296.0	196.9	151.5
1957	6,788.3	2,969.4	332.6	219.2	168.3
1958	7,120.8	3,188.6	364.4	244.7	190.1
1959	7,485.2	3,433.4	403.0	274.0	214.5
1960	7,888.2	3,707.4	436.2	296.2	233.3
1961	8,324.4	4,003.6	464.9	317.8	249.3
1962	8,789.3	4,321.4	502.4	342.6	267.0
1963	9,291.7	4,664.0	531.2	367.5	286.9
1964	9,822.9	5,031.6	574.5	399.8	310.8
1965	10,397.3	5,431.4	627.0	433.9	337.2
1966	11,014.4	5,865.3	653.6	469.0	366.8
1967	11,668.0	6,334.3	718.6	522.2	403.8
1968	12,386.6	6,856.5	774.2	575.0	448.1
1969	13,160.8	7,431.5	839.0	637.8	498.4
1970	13,999.8	8,069.3	954.4	732.1	570.0
1971	14,954.2	8,801.4	1,008.5	782.8	604.8
1972	15,962.7	9,584.2	1,066.2	834.9	638.8
1973	17,028.9	10,419.0	1,135.0	889.1	675.1
1974	18,163.9	11,308.2	1,205.8	943.7	710.4
1975	19,369.7	12,251.9	1,291.2	1,003.2	749.4
1976	20,660.9	13,255.0	1,345.2	1,064.9	790.6
1977	22,006.1	14,319.9	1,421.3	1,135.9	837.1
1978	23,427.4	15,455.9	1,506.3	1,219.1	891.3
1979	24,933.7	16,675.0	1,609.5	1,310.6	957.4
1980	26,543.2	17,985.6	1,597.9	1,335.8	992.9

education wealth, the Fed's household net worth, and Kendrick's total net education and training capital stock. Our education wealth is substantially greater than Kendrick's measure, growing from more than twice in 1950 to over four times in 1970. The comparison of our total human wealth series to the Fed's household wealth is even more dramatic. The ratio is more than four in 1948 and increases by 1980 to more than seven. Human wealth clearly dwarfs household assets.

Figure 5 compares Kendrick's *Total Net Education and Training Investment* to our net change in schooling wealth and school enrollment. At 4 percent, the values we place on schooling are quite a bit greater than Kendrick's capital values. This simply indicates that the value of education exceeds its cost. The difference between the series is value added in the education sector. This value

TABLE 7
AGGREGATE VALUES FOR HUMAN WEALTH, 1946-80, IN BILLIONS OF 1967 DOLLARS, DISCOUNTING AT 10%

Year	Stocks		Net Change		Current Schooling Investment
	Human	Schooling	Human	Schooling	
1946	2,325.79	638.09	46.79	43.30	18.36
1947	2,372.57	681.39	51.40	46.16	20.45
1948	2,423.98	727.55	54.15	48.82	22.18
1949	2,478.13	776.37	55.45	50.39	22.98
1950	2,533.58	826.76	68.15	57.13	26.06
1951	2.601.73	883.89	75.14	59.52	27.32
1952	2,676.88	943.40	79.95	62.64	28.58
1953	2,756.83	1,006.04	82.30	65.84	30.32
1954	2,839.13	1,071.88	85.47	69.51	32.45
1955	2,924.60	1,141.40	103.37	76.79	34.99
1956	3,027.97	1,218.18	114.14	83.08	38.11
1957	3,142.11	1,301.26	131.32	92.02	42.01
1958	3,273.43	1,393.28	141.81	100.39	47.12
1959	3,415.24	1,493.67	154.37	109.98	52.75
1960	3,569.61	1,603.66	168.13	118.85	58.36
1961	3,737.74	1,722.51	178.69	127.07	62.04
1962	3,916.42	1,849.57	195.21	137.43	66.12
1963	4,111.63	1,987.01	203.21	145.86	70.73
1964	4,314.84	2,132.87	222.24	158.85	76.34
1965	4,537.08	2,291.72	238.24	171.58	82.63
1966	4,775.32	2,463.30	251.04	183.68	89.70
1967	5,026.36	2,646.97	278.88	204.67	98.46
1968	5.305.24	2,851.65	298.18	222.58	109.05
1969	5,603.42	3,074.23	322.28	244.51	120.95
1970	5,925.70	3,318.74	368.72	281.62	141.78
1971	6,294.42	3,600.35	392.86	302.90	150.24
1972	6,687.28	3,903.26	418.71	325.39	158.32
1973	7,106.00	4,228.64	447.65	349.24	167.24
1974	7,553.65	4,577.88	477.58	373.80	175.78
1975	8,031.23	4,951.68	511.52	400.43	185.29
1976	8,542.75	5,352.11	540.10	427.91	195.12
1977	9.082.85	5,780.02	574.68	458.64	205.70
1978	9,657.52	6,238.66	612.07	492.90	217.78
1979	10,269.60	6,731.56	654.54	530.58	232.54
1980	10,924.13	7,262.14	648.29	538.74	238.07

added is a part of national income not measured in the conventional accounts, where education is valued at cost.[25]

5. CONCLUSION

The first point to emphasize is the pattern of appreciation and depreciation of human wealth over the lifetime of an individual. This phenomenon should induce a counterbalancing pattern in the conventionally defined marginal propensity to save. Hence, the ageing of the baby boom generation should generate a cycle in the nation's savings rate. Not only is this cohort exceptionally large,

[25]In fact, since Kendrick includes the opportunity cost of a student's time, his costs are greater than the conventional measure.

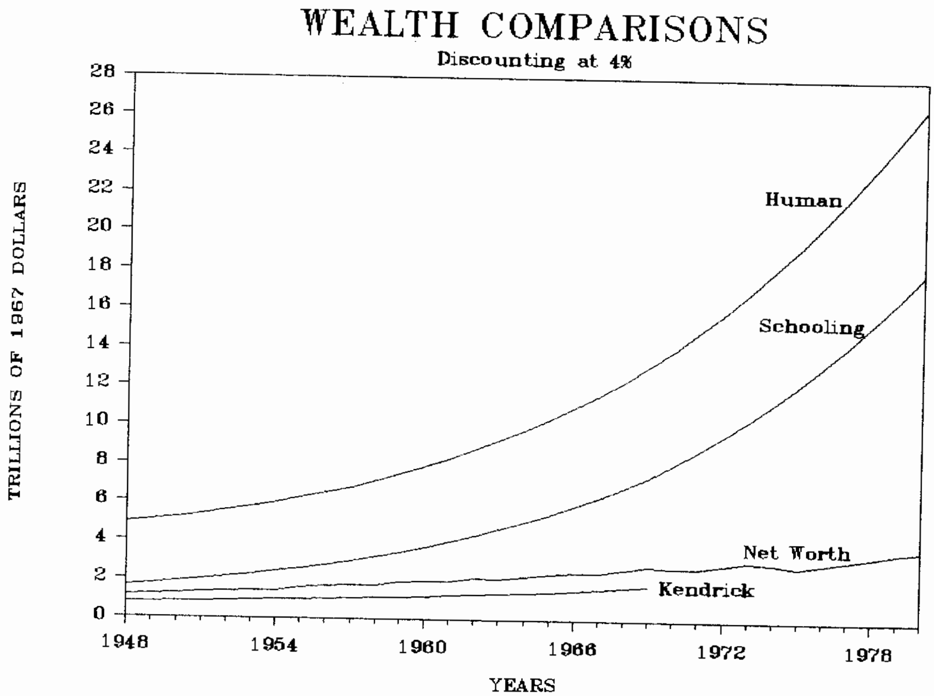

Figure 4

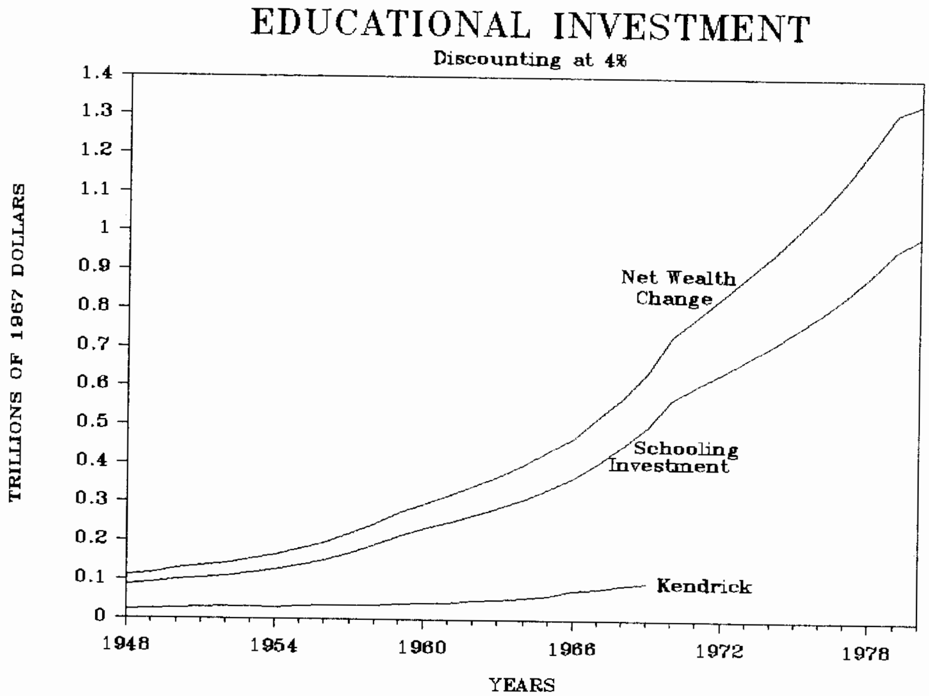

Figure 5

it is also more highly educated than those that proceeded it. Education increases the age of peak human wealth and thus should shorten the period during which individuals save for retirement. Similarly, the greater is the interest rate used to discount future earnings, the later is the date at which human wealth starts to depreciate.

The second point to emphasize is the magnitude of our human and schooling wealth estimates. On average for the period (discounting at 4 percent) human wealth is five times—and schooling wealth 2.6 times—the Federal Reserve Board's measure of household net worth. And as Figure 4 depicts, these ratios increase over the period. The value of schooling conducted in any year greatly exceeds its cost. Conventional measures of national income do not count this value added. Furthermore, schooling represents a form of saving whose value is several times the conventional measure of saving.

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