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The Effect of School Quality on Achievement, Attainment Levels, and Lifetime Earnings

ABSTRACT: This study provides a comprehensive examination of the relationship between the quality of schools and colleges attended and lifetime economic behavior. Previous studies have been concentrated almost exclusively on the quantity of schooling. In this study, the effects of school quality and length of schooling are examined with some highly disaggregated cross-sectional data. ¶ The data set (NBER-TH) used here was first compiled by R. L. Thorndike and E. Hagen in the mid-1950s and has since been extended by the National Bureau. In the analysis, the lifetime economic histories of the NBER-TH respondents were combined with quality data for the school district in which the respondent attended high school and for the colleges he attended. These data were used to estimate some simple recursive models. In the first model, family background and school quality were exogenous, and the endogenous variables were achievement as measured by army tests, quantity of further schooling, and lifetime earnings. Significant school quality effects on achievement and earnings were found. In subsequent models, a measure of college quality is included as an additional intervening variable. There were significant

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school quality effects on the quality of college attended, and both school and college quality were found to be important determinants of earnings.

[1] INTRODUCTION

Research on the effects of schooling has, in recent years, shifted from the unbridled optimism of the early rate-of-return studies (e.g., Schultz and Becker) to the pessimism and frustration exhibited in the Coleman Report and in *Inequality* by Jencks et al. (1972). Fundamental to these widespread differences in outlook is the question of whether school quality affects the outputs of the schooling process, an issue that arises because, in general, the relationship between resource inputs into schooling and schooling outputs is not well understood. In this paper, I address the question using some broad measures of school output that extend over the life cycle of the students, a type of data not previously examined in this context. The evidence indicates that school quality does have an important effect on lifetime economic behavior.

The educational production process is complex because there are multiple inputs and outputs. Without attempting to specify a production function we can conceptualize the components of the relationship. Among the outputs, we would include the pecuniary value of education and the nonpecuniary value of job situation, intellectualism, knowledge, literacy, etc., as well as the value to society of an educated public, which is more likely than an uneducated one to be committed to certain human and political values. These outputs are difficult to specify and even more difficult to measure and are interrelated over the life cycle. On the input side we would want to separate preschool learning endowments, both genetic and environmental, from the resource inputs of the school, which include teacher quality, curriculum, physical plant, and supplies, as well as intangibles such as community attitudes and peer group influences. Furthermore, the distinction between outputs and inputs is often blurred; the output of one stage of schooling is the input of another.

There have been several studies of the production function for education in which the effect of school resources on student achievement scores was examined, e.g., Hanushek (1972), Kiesling (1967), and Raymond (1968). These studies were limited to one output of schooling, measured achievement. Jencks's work can be viewed as an effort to extend the research to include outputs observed later in the life cycle by synthesizing various results. Jencks concludes that school quality is only a minor factor among the overall determinants of earnings, but he does not shed very much light on the size of the payoffs to marginal changes in inputs.

The effect of college quality on earnings has been studied by several authors. Solmon and Wachtel (1975), Solmon (1975), and Taubman and Wales (1973) all use the NBER-TH data on which my analysis is based (see section 2, below). One of only a few other studies is by Sewell and Hauser (1972). Only three studies of the effect of precollege school quality on earnings can be found, those by Morgan and Sirageldin (1968), Johnson and Stafford (1973), and Welch (1966). All of them are of fairly limited scope; the first two use a single highly aggregated measure of school quality (statewide average expenditures) and the third uses aggregate earnings data as well.

The problem of analyzing the effects of schooling inputs may seem intractable.[1] However, in this paper I reduce the problem to manageable size by specifying a fairly simple recursive model that relates a small group of inputs and outputs. The specification relies heavily on the analyses in the human capital literature, in particular, Mincer (1970) and Chiswick and Mincer (1972). Models of this type have been used to analyze the relationship among ability, schooling, and income, but not school quality (see Griliches and Mason 1972). The specification and estimation of the model are preceded by a description of the data set used in this study, the NBER-TH sample.

[2] THE NBER-TH DATA SET

The NBER-TH data set was originally put together in the mid-1950s for a study of occupational choice by Thorndike and Hagen (1959) of Columbia Teachers College. They drew a sample from a large group of men who in 1943 volunteered for Army Air Force pilot and navigator training programs. These men were all in the army at the time, all between ages 18 and 26, and all presumably in good health. They had also taken a preliminary screening test based on scholastic achievement with a technical or mechanical emphasis. The passing level was set so as to qualify half the high school graduates in a national sample. The men were then given a large battery of tests which, along with biographical information, determined whether they were chosen for the training program.

Thorndike and Hagen surveyed a sample of these respondents by mail in order to supplement the military data with educational, occupational, and earnings data. In 1968–1969, in order to bring the information on education and earnings of the Thorndike respondents up to date and add to the background data, the NBER first updated their addresses, using army serial numbers and Veterans Administration files. Mail questionnaires were then sent out to the 7,500 people for whom current addresses had been obtained. Responses were received from almost 5,100. Later questionnaires dealing with additional aspects of family background were sent out in 1970 and 1971.

The NBER-TH data set is unique in that it combines extensive background and education data and information on both earnings and occupation over a large part of the life cycle, with a variety of achievement, ability, and aptitude test scores.[2] Even the name and location of the high schools and colleges the respondents had attended were provided. Thus, the basic data for a study of the effects of school quality were available.

However, there is in fact very little data available on the quality of primary and secondary schools. Primary data collection was out of the question because it was considered unlikely that the school records would be available for the prewar years, when the respondents were in high school. Retrospective questions given to respondents in the 1971 and 1972 questionnaires were useful in obtaining much data on their childhood experiences, but it was impossible to obtain information on school experiences in this fashion. Individuals simply do not have any accurate information that can be used objectively to assess the schools they attended. The only school data collected in this way were basic information on the type of school attended—public, private, or parochial—and the type of program—vocational or academic.

Consequently, the basic source of data was the Biennial Survey of Education published by the U.S. Office of Education. From the mid-nineteenth century until very recently, OE education statistics were based on complete censuses of school districts. Unfortunately, the original records have been destroyed, but the published surveys for the prewar period include data for individual school districts. It was decided to use data from the 1936–1938 survey in order to insure consistency and to simplify the data-collecting task. Virtually all of the respondents were in school at that time (the mean age in 1937 was 15).

In the 1969 survey, the respondents were asked to name their high school and give its location. This rough information had to be matched one by one with the school district names. A great deal of time was spent, therefore, in detective work to maximize the number of matches. Not all the respondents supplied the name of their school and the OE school district data omit countywide districts in several states and some others which did not provide data. As a result, quality data based on school district information are available for 46 percent of the NBER-TH respondents. The school district is probably a sufficiently disaggregated level for the analysis as most districts have one or two high schools and a handful of primary schools.[3]

[3] THE STRUCTURE OF THE MODEL

The outputs of the educational process that are considered in this paper are determined sequentially over time. Therefore, a recursive model describes the process by which school quality and student background affect lifetime behavior. Of necessity only a small set of outputs will be explained, but they are diverse measures of effects of schooling that are widely spread out over the life cycle. The inputs other than prior outputs are the various measures of school quality and student background.

Model I is summarized by the following equations, with expected coefficient signs indicated; the symbols are identified in Table 1.

$$A = \alpha_0 + \underset{(-)}{\alpha_1 SIB} + \underset{(+)}{\alpha_2 MED} + \underset{(+)}{\alpha_3 FED} + \underset{(+)}{\alpha_4 QS} + U_A$$

$$S = \beta_0 + \underset{(-)}{\beta_1 SIB} + \underset{(+)}{\beta_2 MED} + \underset{(+)}{\beta_3 FED} + \underset{(-)}{\beta_4 AGE} + \underset{(+)}{\beta_5 QS} + \underset{(+)}{\beta_6 A} + U_S$$

$$Y69 = \gamma_0 + \underset{(+)}{\gamma_1 FED} + \underset{(+)}{\gamma_2 EXP} + \underset{(+)}{\gamma_3 LNH} + \underset{(+)}{\gamma_4 QS} + \underset{(+)}{\gamma_5 A} + \underset{(+)}{\gamma_6 S} + U_Y$$

The model determines post-high-school achievement scores (*A*), total number of years of schooling (*S*), and real earnings in 1969 (*Y69*). The exogenous inputs that determine an individual's skills and performance are genetic endowment and home investments in human capital. Neither of these factors can be measured directly, but a number of proxies have been suggested; the ones included in the model are family size and parents' education. Variables are included to measure other incentives for human capital investment and the returns to nonschooling investments.

Relationships Hypothesized in the Model

The dependent variable in the first equation is a composite constructed from scores on various tests the NBER-TH respondents took in 1943. The original tests were designed to measure aptitude for pilot and navigator training. A factor analysis was used to weight the scores and combine them into a single measure of ability.[4] Virtually all the respondents had completed high school when tested, and therefore this ability or achievement measure was the product of genetic endowment, home investment, and precollege schooling. The background variables, mother's and father's education (*MED* and *FED*, respectively) and family size (number of siblings, *SIB*) are used as proxies for genotype and family wealth. Background also determines home-related human capital investments.[5] This is because higher-educated parents are thought to spend more time with their children and to be better able to encourage development. In addition, children from large families tend to get less attention than those in small ones. Family size is also an indicator of socioeconomic status; lower-status families tend

TABLE 1 Definitions and Statistics of Variables in School District Sample ($N = 1{,}812$)

		Mean	Standard Deviation
A	Test score	0.1292	1.7972
SIB	Number of siblings[a]	2.876	1.529
MED	Mother's education[b] (years)	9.864	3.331
FED	Father's education[c] (years)	9.799	3.763
S	Years of schooling	15.134	2.339
AGE	Age in 1969	46.54	4.12
EXP	Years of work experience	21.060	7.053
LNH	Natural log of hours worked	3.795	0.177
H	Hours worked	45.18	8.11
Y69	Natural log of 1969 earnings in thousands of real (1958) dollars	2.596	0.461
*Y69**	1969 earnings (thous. 1958 dol.)	15.09	8.56
QS	Current school expenditures per student in average daily attendance for school district in which respondent attended high school (thous. dol.)	0.107	0.034
SY	Median income in state of high school, from 1940 census (thous. dol.)	1.062	0.180
QC	Total direct expenditures for post-secondary schooling (thous. 1962–1963 dol.) $= S_U E_U + S_G E_G$, where S_U and S_G are years of undergraduate and graduate schooling and the *E*s are per student expenditures[d]	4.942	4.562
QG	Gourman score for undergraduate school[e]	484.2	115.0

[a]Median value assigned when respondent supplied no information (about one-third of the NBER-TH sample).
[b]Value of 10 assigned for nonresponses (17 percent of NBER-TH sample).
[c]Value of 7 assigned for nonresponses (6 percent of NBER-TH sample).
[d]$QC = 0$ for those who did not attend college (20.7 percent of sample).
[e]For those who attended college only, $N = 1{,}437$.

to have more children than families of higher status. The final variable in the equation is a measure of school quality (*QS*).[6]

The second structural equation explains the number of years of post-secondary schooling attained. Background measures and school quality enter in the same way and for the same reasons: there may be family background and school effects on productivity in college which are not reflected in measured achievement. In addition, the amount of schooling is determined by the opportunities for and costs of human capital investments. Because access to capital markets for schooling investments is limited, schooling opportunities are determined by family financial considerations. In the absence of family income or wealth data, father's education is taken as a proxy. The respondent's age (*AGE*) enters this equation negatively because the opportunity costs of schooling increase over time. It is an important determinant of schooling in this sample because the average age of the respondents when the war ended was 23. It is likely that some respondents decided not to pursue further education because of their age.

Finally, the test score enters the schooling equation because more able students may be more productive. That is, they are likely to gain more in terms of skills and earnings capacity from a year of schooling than lower-scoring students, and since their marginal returns are higher they will invest in more schooling.[7] Parsons (1974), Morgenstern (1973), Johnson and Stafford (1973), and Leibowitz (1974b) estimate schooling demand equations that depend on family background.[8] Their models reveal background effects on attainment similar to mine.

The final equation is an earnings function that draws on the human capital literature. The dependent variable is the natural log of full-time earnings in 1969 deflated to 1958 dollars. The semilog form of the equation is based on the Becker and Chiswick (1966) derivation, which is also discussed in Chiswick and Mincer (1970). Heckman and Pollachek (1974) provide some empirical support for the statistical superiority of this specification. The choice of variables included in the *Y69* function is based on the discussions of human capital earnings function: years of labor force experience, which is measured from the first postwar job, reflects the positive returns to on-the-job training. The hours worked variable is included to standardize for variation in work effort.[9] Total years of schooling and the school quality variable are measures of human capital investment.[10] The achievement score is an additional measure of innate human capital or initial earnings capacity. Father's education can be considered as a measure of family status or wealth; both affect earnings either directly or through their effects on access to job opportunities. For this reason father's education and not any of the other background variables enters the earnings function directly. Neither family size nor mother's education have a significant direct effect on 1969 earnings.

An additional intervening variable that is added in models II and III is college quality. Attendance at a college of a particular quality is determined by post-high-school achievement, family background, and school quality. College quality affects the total number of years of college attended and earnings. The appropriate specification of college quality in the model will be discussed in section 5.

Estimation Procedure

It is assumed that the model satisfies the conditions for estimation of a recursive model by ordinary least squares on each equation; that is, the variables are sequential, and the residuals in each equation are independent. This assumption does seem heroic; we would expect that omitted background variables that affect *A* would also affect *S* and *Y*. However, the correlations among estimated residuals for Model I were very small. Nevertheless, in future work simultaneous equation techniques should be used to estimate the model or additional coefficient constraints should be imposed so that the model will be exactly identified. Experiments with two-stage least squares estimation of the earnings equation were unsuccessful because there are currently too few instruments in the model.

[4] ESTIMATION AND RESULTS: MODEL I

The model was estimated on a subsample of the NBER-TH respondents. Eliminated from the sample were airplane pilots, respondents who were unmarried or who reported poor health in 1969, and respondents whose real (1958 dollar) earnings were outside the range of $4,000 to $75,000 in 1955 and the range of $5,000 to $75,000 in 1969. In this way, some erroneous data were eliminated, and the sample was made somewhat more homogeneous. However, the principal reason for the reduction in the sample size from 5,084 respondents to 1,812 was the unavailability of school quality data for the respondent's school district. Respondents who attended private or parochial schools were also eliminated because no school quality data are available for nonpublic schools.[11]

In Table 2 estimates of Model I without a school quality variable (i.e., $\alpha_4 = \beta_5 = \gamma_4 = 0$ by assumption) are presented in the odd-numbered equations; and estimates with the variable, in the even-numbered equations. The school quality variable is total current expenditures per student in average daily attendance in the respondent's school district.[12]

All the coefficient estimates are at least twice their standard errors with the single exception of *QS* on *S*, for which the coefficients were consistently insignificant.[13] A possible explanation of this result is that the respondents with superior precollege education had a high earnings potential after their military service and therefore found the costs of further schooling prohibitively high, indicating a negative relationship between *QS* and *S*. Alternatively, it could be argued that student stipends under the GI Bill encouraged respondents with an inferior precollege education to make up any deficiencies.

One of the striking features of Table 2 is the absence of collinearity between school quality and the other variables. None of the coefficients for exogenous background variables is changed very much when quality is added. Only the *FED* coefficient in the earnings function changes by more than 10 percent. The achievement coefficient in the earnings equation is reduced by only 5 percent. School quality affects earnings directly and has, in addition, an indirect effect through achievement. The achievement score

TABLE 2 Regression Estimates of Model I
(figures in parentheses are standard errors of the coefficients)

	A		S		Y69	
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	−0.5459	−0.8764	15.9024	15.8848	−0.4305	−0.685
SIB	−0.0666 (0.0276)	−0.0635 (0.0276)	−0.0761 (0.0346)	−0.0759 (0.0347)		
MED	0.0327 (0.0143)	0.0349 (0.0143)	0.0539 (0.0179)	0.0540 (0.0180)		
FED	0.0556 (0.0126)	0.0556 (0.0125)	0.0533 (0.0158)	0.0533 (0.0158)	0.0064 (0.0027)	0.007 (0.002
AGE			−0.0353 (0.0127)	−0.0354 (0.0127)		
EXP					0.0076 (0.0016)	0.0076 (0.001
LNH					0.4887 (0.0560)	0.501 (0.055
QS		2.7985 (1.2152)		0.1629 (1.5263)		1.837 (0.284
A			0.3167 (0.0294)	0.3165 (0.0295)	0.0384 (0.0058)	0.036 (0.005
S					0.0625 (0.0050)	0.0626 (0.005
R^2	0.0292	0.0320	0.1022	0.1022	0.1751	0.193

NOTE: Variable definitions are given in Table 1. Sample size is 1,812.

has strong direct effects on earnings and an indirect effect through schooling level.

Although father's and mother's education are correlated with each other (the simple correlation is 0.47), the results indicate that they have independent effects on both achievement scores and schooling attainment. Arleen Leibowitz (1974a) argues that mother's education is a proxy for human capital investment at home since mothers are more responsible than fathers for child rearing, and efficiency and time spent in child care increase with mother's education. Consequently, *MED* should have a larger effect than *FED* on human capital investments. This is not observed in the Table 2 results because of measurement error in *MED*: more observations are missing for *MED* than for *FED*. However, the *MED* coefficients are much larger than the *FED* ones when the ability and attainment equations are estimated for respondents with completed data only.[14]

An alternative presentation of the results may be seen in Figure 1 where a path diagram for the preferred version of Model I (with $\beta_5 = 0$) is shown. The path coefficients are simply beta coefficients or standardized regression coefficients calculated from Table 2, equations 2, 3, and 6.[15] The advantage of this presentation, which is used extensively by model builders in social sciences other than economics, is that it gives a concise and clear summary of the whole structure hypothesized and of the strength of the various relationships.

The diagram shows quite clearly that the direct effect of the school quality variable on *A* and *Y69* is as strong as the effect of most background and intervening variables. Only hours worked and years of schooling have larger direct effects on earnings. The direct test score and school quality effects on earnings are equal. The effect of school quality on earnings has an indirect component through the test score (0.05 × 0.14 + 0.05 × 0.24 × 0.32 = 0.011) which is negligible compared to the direct effect (0.14). The indirect effect of school quality on schooling attainment is 0.012 (= 0.05 ×

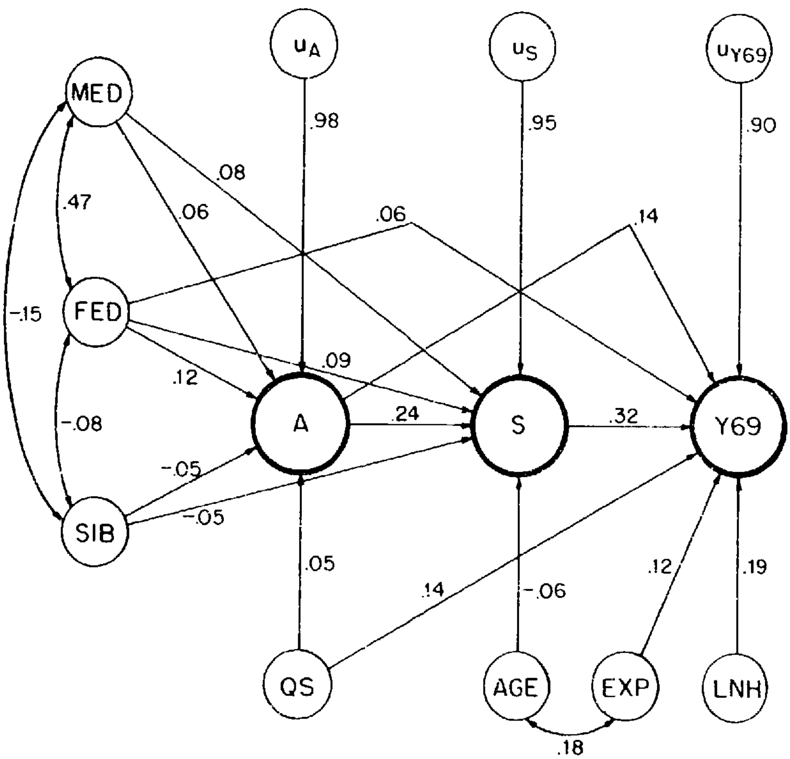


FIGURE 1 Path Diagram for Model I

0.24). The effect of *FED* on earnings can be decomposed into direct and indirect components as follows:

Direct:	(0.06)
Indirect through ability:	(0.12)(0.14) + (0.12)(0.24)(0.32) = 0.026
Indirect through schooling:	(0.09)(0.32) = 0.028

The other background variables have very small indirect effects on earnings. It is somewhat puzzling that the background variables have larger direct than indirect effects; the possibility of measurement errors and specification bias does exist.

Although the school quality variable is statistically significant, reasonable variation in school quality has only a very limited effect on the earnings distribution. For example, if the typical respondent attended a school with expenditures one standard deviation above the mean, 1969 real earnings would be increased by 6.2 percent. One standard deviation of expenditures corresponds to an increase of 32 percent. By comparison, an increase of one standard deviation in *FED* would lead to an increase in average earnings of 24 percent.

Another way of viewing the importance of school quality is by looking at the trade-off between increased precollege schooling expenditures and time spent in college. An increase of one standard deviation in school expenditures has the same effect on earnings as an additional year of post-secondary schooling. However, such an increase in school expenditures maintained for twelve years of schooling would be less costly than an additional year of full-time college attendance. In an earlier paper, I estimated the average opportunity cost for college attendance for the NBER-TH respondents as $4,744 in 1959 dollars. In addition, direct social costs are $1,490. Assuming that students' part-time earnings are one-fourth of full-year earnings, the social cost (in 1959 dollars) of a year of college is $5,048. The cost of an increase in school expenditures with the same effect on earnings is only $408 (12 × $34) in 1937. With any reasonable allowance for inflation between 1937 and 1959, the cost of the increased school expenditure is likely to be less than the direct social cost of an additional year of college. Thus, it is certainly advantageous to maintain high-quality education at an early age, rather than to prolong the educational process. This conclusion is necessarily tentative because the large changes suggested in school expenditures are beyond the range of variation found in the sample.[16]

Comparative Evaluation of School Expenditure Effects

The estimates of the school expenditure effects can be interpreted in several ways which allow some comparison with previous studies. To begin, an estimate of the earnings elasticity of school expenditures is given by:

$$\frac{d \ln Y^*}{dQS} \overline{QS} = 1.8377 \times 0.107 = 0.197$$

This estimate is, most surprisingly, virtually identical to that of Johnson and Stafford (1973), 0.198. However, my estimates suggest a stronger trade-off between school expenditures and years of schooling. The statistic used by Johnson and Stafford is:

$$\frac{dS}{dQS}\Big|_{dY = 0} = -\frac{dY}{dQS} \div \frac{dY}{dS}$$

Evaluating the derivatives at the means (and converting QS to dollars) yields a value of −0.029; that is, a dollar increase in QS produces the same amount of human capital as an input of 2.9 percent of a year's additional schooling. The equivalent estimate in Johnson and Stafford is 0.9 percent.

Johnson and Stafford (1973) and Morgan and Sirageldin (1968) also estimate marginal returns to school expenditures. Their estimates are 12–14 percent and about 15 percent, respectively. I am reluctant to use the estimated earnings functions to estimate rates of return on per student expenditures because the earnings profiles for a single year may not be a fair representation of life cycle earnings behavior. However, Lillard (1973) has done an extensive investigation of the earnings profiles of the NBER-TH respondents which he uses to make some suggestive estimates of returns. In the discussion that follows, Lillard's estimates of the present value of lifetime earnings for the NBER-TH respondents are combined with my estimates of the school quality effect on earnings to measure the return on schooling expenditures.

An estimate of the rate of return (R) is derived from the following familiar relationship:

$$(1) \quad \sum_{i=6}^{17} \frac{\Delta C_i}{(1 + R)^{i-16}} = \sum_{i=18}^{65} \frac{\Delta E_i}{(1 + R)^{i-16}}$$

where i is the age of the respondent; ΔC, an increment in school costs; ΔE, the resulting increment in earnings; and R, the internal rate of return on public school expenditures. The left-hand side of (1) is the present value at age 16 of an increase in expenditure of \$1 per year maintained for twelve years of schooling.

On the earnings side, we would like to have estimates of the earnings increment in every year of working life caused by a \$1 increment in school expenditures. The earnings function (Table 2, equation 6) provides an estimate of $d \ln Y69^*/dQS$ or the percentage increment in real 1969 earnings due to a change in expenditures. I will assume that this percentage is constant over the work life.[17] A $1 increase in QS (in 1937–1938 dollars) increases earnings by 0.1838 percent. Since all earnings data are in 1958 dollars I use the Bureau of Labor Statistics Consumer Price Index to adjust the coefficient. The percentage growth in earnings per $1 increase in expenditures in 1958 dollars is 0.1838 × (1/2.02) = 0.0910.

Using these assumptions we can rewrite the right-hand side of (1) as

$$(2)\quad \sum_{i=18}^{65} \frac{0.00091\, E_i}{(1+R)^{i-16}} = 0.00091\, PVE\,(R)$$

where $PVE(R)$ is the present value of lifetime earnings at age 16 discounted at rate R. Lillard presents estimates of PVE for alternative values of R.[18] Costs are equal to benefits when R is 12.6 percent, using earnings for respondents with 16 years of schooling and mean ability.

The rate of return will change by less than a percentage point if predicted lifetime earnings of persons with ability one standard deviation above or below the mean are used. However, the returns estimate increases to 15.2 percent for persons with only a high school degree and decreases to 11.8 percent for those with professional or doctoral degrees. The returns estimate is fairly sensitive to changes in the cost assumptions or the size of the quality coefficient. If the quality coefficient from the 1955 earnings function is used (see section 6, below) the rate of return is 9.4 percent.

In the remainder of this section, the Model I results are used to determine whether the level of school expenditure is simply a proxy for community income; the model is extended by re-estimating it, using alternative measures of school quality; and the stability of the variables in terms of interactions between QS and ability and city size is investigated.

School Expenditure Levels as a Proxy for Community Income

School expenditures are often viewed as a proxy for background effects rather than as a measure of school quality. For this reason some additional tests are presented in order to demonstrate that the school quality effects indicated by the estimates of Model I are genuine. The quality variable could be a proxy for unmeasured family background variables or family wealth, as well-off families tend to live in districts with above-average expenditures. It could also be a proxy for regional income differentials that persist from one generation to another. In either case, I would interpret the school quality results quite differently in terms of their implications for educational policy. However, a direct test of these alternative interpretations demonstrates convincingly that we are observing school quality effects.

In Table 3 two alternative versions of Model I are shown. An additional variable, SY, is median income in the state of the respondent's high school

TABLE 3 Test of School Expenditures as a Proxy for Community Income
(figures in parentheses are standard errors of the coefficients)

	A		*S*		Y69	
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	−1.1799	−1.1548	16.4469	16.5045	−0.5970	−0.5399
SIB	−0.0629	−0.0623	−0.0792	−0.0784		
	(0.0276)	(0.0276)	(0.0346)	(0.0346)		
MED	0.0357	0.0360	0.0511	0.0515		
	(0.0143)	(0.0143)	(0.0180)	(0.0180)		
FED	0.0566	0.0563	0.0523	0.0519	0.0069	0.0067
	(0.0126)	(0.0126)	(0.0158)	(0.0158)	(0.0027)	(0.0026)
AGE			−0.0352	−0.0356		
			(0.0127)	(0.0127)		
EXP					0.0077	0.0075
					(0.0016)	(0.0016)
LNH					0.4956	0.4958
					(0.0560)	(0.0554)
QS		1.6893		2.5838		2.3028
		(1.5192)		(1.9045)		(0.3560)
SY	0.5494	0.3547	−0.4784	−0.7755	0.1179	−0.1483
	(0.2333)	(0.2916)	(0.2927)	(0.3655)	(0.0552)	(0.0684)
A			0.3194	0.3183	0.0375	0.0369
			(0.0295)	(0.0295)	(0.0058)	(0.0057)
S					0.0630	0.0619
					(0.0050)	(0.0050)
R^2	0.0322	0.0328	0.1035	0.1045	0.1772	0.1958

NOTE: Variable definitions are given in Table 1. Sample size is 1,812.

in 1939 (from the 1940 Census) in thousands of dollars. It is a proxy for the neighborhood wealth effect or the regional income differential. The odd-numbered equations include *SY* but not *QS*. These results look very much like the estimates of Model I with *QS* (Table 2, even-numbered equations). Median income enters the achievement and earnings equations with significant positive coefficients. In the earnings equation it makes a smaller contribution to explained variance (0.0021) than does the school quality variable (0.0186), but in the achievement equation it is more important. Nevertheless, it would be difficult to distinguish the model with *SY* from the school quality model. The doubts raised by these estimates are set to rest by the even-numbered equations in Table 3, which include both *QS* and *SY*. In the essential equation for *Y69*, the *QS* coefficient is significant and the *SY* coefficient is negative. These results are consistent with the interpretation that we are, in fact, capturing the effect of school quality in these data.[19]

The significantly negative coefficient on *SY* may have some justification. It can be interpreted as a relative income effect. The coefficient of *SY* (i.e., $dY69/dSY = -0.1483$) can be transformed into a coefficient of the reciprocal of *SY* [i.e., $dY69/d(1/SY) = +0.1666$] when *SY* is evaluated at its mean (1.06).[20] That is, we can view the *SY* and *QS* variables in equation 6, Table 3, as linear approximations of the specification including *QS/SY*. The coefficients of *QS* and *SY* can then be written as 0.1666 (*QS/SY*) + 2.2362 *QS*. Thus, we have both a positive relative expenditure effect and a direct expenditure or quality effect.[21] To conclude, the results do show that the influence of school quality is not diminished when state income is held constant.

Estimates Using Alternative Measures of School Quality

Up to this point, the discussion has concentrated exclusively on a single measure of school quality. There are numerous other measures available from the same Office of Education school district data.[22] However, the quality variables tend to be highly correlated. As a result it is not feasible to try to pinpoint the relative impact on earnings of the various components of school expenditures. However, it is useful to examine some of the other variables as alternative measures of *QS* in Model I. A summary of the quality results is shown in Table 4.

The Office of Education data provide two measures of physical resource inputs into the educational process: teacher-pupil ratios and length of the school year. Neither variable appears to have a strong effect in the model. It is in fact quite disappointing to find that only budgetary measures have significant quality effects. A possible explanation of this paradox is that there is much more intradistrict variation in expenditures and salaries than in the available physical measures of inputs. The coefficient of variation for total expenditures and average salaries is about 3.0, while for the student-teacher ratio it is 7.7, and for length of term it is 29.9. There have been secular trends toward standardization in class size and length of the school term since the late nineteenth century; and as early as the late 1930s there was relatively little variation from the norm. Thus, existing data provide a poor test of the potential benefits of smaller classes and a longer than usual school term. Another quality measure shown in Table 4 is the average number of pupils per school building, a measure of the scale of the school district. The results suggest that there are some scale effects on earnings.

The quality coefficients on earnings in Table 4 show the impact of quality improvements. For example, establishment of year-round schooling (225 days per year, instead of 182) would increase earnings by 20.6

TABLE 4 Coefficients of Alternative Measures of School Quality in Model I[a] (figures in brackets are beta coefficients)

School Quality Measure	A	S	Y69	Mean (Stand. Dev.)
Teacher-pupil ratio	15.04 [0.03]	33.93* [0.06]	0.7806 [0.01]	0.0307 (0.0040)
Average teacher salary (thous. dol.)	0.1323* [0.05]	−0.0640 [−0.02]	0.1131* [0.16]	1.980 (0.638)
Average enrollment per building (hundreds of pupils)	0.0108 [0.02]	−0.0140 [−0.02]	0.0211* [0.13]	6.918 (2.921)
Length of school year (days)	0.0106 [0.04]	−0.0042 [−0.01]	0.0048* [0.06]	182.2 (6.1)
Current expenditures per average daily attendance (QS)[b] (thous. dol.)	2.7985* [0.05]	0.1629 [0.00]	1.8377* [0.14]	0.1070 (0.034)
Expenditure on texts and other expenses for instruction per average daily attendance (thous. dol.)	0.0396 [0.0]	19.4833 [0.01]	11.4778* [0.04]	0.0037 (0.0018)
Ratio: Average teacher salary to state median income	0.0456 [0.01]	0.0033 [0.0]	0.1360* [0.15]	1.8696 (0.5062)

*Coefficient is more than twice its standard error.
[a]The equations of Model I are re-established with each alternative measure as a replacement for QS.
[b]These regressions are shown in Table 2, equations 2, 4, and 6.

percent. Similarly, doubling the number of teachers per pupil would increase earnings by 10.6 percent (this estimate includes both the direct effect and indirect effects through *S* and *A*).[23]

A more detailed breakdown of expenditures can be obtained by using statewide quality data or data for the urban and rural areas of each state. Although the potential sample is more than doubled, the results are very similar, indicating that the school district sample of 1,812 respondents does not have any sampling bias. Instructional costs per student have a somewhat stronger effect than the other components of total current expenditures. All the dollar measures have significant positive effects on Y69 and *A*, but not on *S*. Capital costs and the value of school property have similar but weaker effects.

Stability of the Variables

One of the conceptual problems in making policy inferences from the model is that it is not clear that the coefficients are stable. The problem of secular stability, that is, whether these retrospective observations are valid prospectively, cannot be examined here. But the problem of stability over different components of the sample can be investigated.

The first such question relates to the regional effects discussed earlier. We know that large communities spend more on schooling than do small and rural ones. This reflects higher living costs, higher property and maintenance costs, and perhaps higher-quality schooling as well in the large communities compared with the others. If there are payoffs to higher schooling expenditures when the sample is divided by size of locality, that would be further evidence of the existence of school quality effects as distinct from city size effects. It can be argued that the school quality effects in the whole sample are merely due to the combination of returns to scale and the coincidence of large scale in cities with higher costs. If school quality effects are significant in the large- and small-city estimates separately, we can argue that this is not the case.

These hypotheses are tested by estimating Model I for the subsample of respondents who attended school in cities with a population of over 100,000 (there are 40 such cities in the sample). The coefficients of two alternative quality variables are shown in Table 5. Results using per pupil current expenditures as the quality variable are shown in the upper part. On average, per pupil expenditures are 27 percent higher in the large cities than in the small ones. The direct quality effect on earnings is much larger for students who attended large-city schools. However, the quality coefficient on *A* is much smaller. Similar results are found for the length of the school year, shown in the lower part of the table. Large-city schools were in session an average of two days more than small-city schools. The direct effect of this quality measure on earnings is also stronger for large cities than for small ones. Chow tests were used to test the homogeneity of each equation of the model with respect to city size. The null hypotheses of no difference in the vector of coefficients can be rejected at the 5 percent significance level for the *Y69* equations only.

The specification of the model rules out any interaction of school quality with the other determinants of earnings, other than that provided by the log-linear functional form. Of particular interest is the interaction between school quality and ability.[24] To examine this relationship the test score, *A*, is viewed as a measure of native intelligence rather than as the product of school quality (in this case $\alpha_4 = 0$ in Model I). The possibility of an interaction between *A* and *QS* in determining *S* and *Y69* can then be tested, the implication being that the more intelligent an individual is, the more he or she profits from high-quality schooling. The results in Table 5 show no interaction between school quality and test score in the earnings equation, although the expenditure effect is slightly higher for the below-average students.[25] However, the effect of quality on schooling attainment is positive for the high-ability group and negative for the low-ability group.

TABLE 5 School Quality Coefficients in Model I by City Size and Ability Groups (figures in brackets are beta coefficients)

	A	S	Y69	Quality Mean (Standard Deviation)
	Current Expenditures per Average Daily Attendance			
Large cities	1.2979	−4.1247	2.9506*	0.1262
(N = 504)	[0.02]	[−0.06]	[0.20]	(0.032)
Small cities	3.3694*	2.4233	1.0211*	0.0995
(N = 1,308)	[0.04]	[0.03]	[0.07]	(0.032)
Total	2.7985*	0.1629	1.8377*	0.1070
(N = 1,812)	[0.05]	[0.00]	[0.14]	(0.034)
F value for Chow test	1.00	1.14	2.59	
Above mean A		2.7179	1.6601*	0.1079
(N = 852)		[0.04]	[0.12]	(0.033)
Below mean A		−2.1005	1.9551*	0.1061
(N = 960)		[−0.03]	[0.16]	(0.036)
F value for Chow test		2.20	0.59	
	Length of School Year			
Large cities	−0.0068	−0.0250	0.0074*	183.6
	[−0.02]	[−0.06]	[0.09]	(6.1)
Small cities	0.0161*	0.0051	0.0020	181.6
	[0.05]	[0.01]	[0.03]	(6.0)
Total	0.0106	−0.0042	0.0048*	182.2
	[0.04]	[−0.01]	[0.06]	(6.1)
F value for Chow test	1.37	0.99	3.49	
Above mean A		0.0163	0.0056*	182.3
		[0.04]	[0.08]	(6.2)
Below mean A		−0.0250	0.0038	182.1
		[−0.06]	[0.05]	(6.0)
F value for Chow test		2.69	0.56	

*Coefficient is more than twice its standard error.

We can conjecture that the less able student with low-quality precollege schooling attends college for "compensatory" education, while the more able students find their productivity in college enhanced by quality schooling and they obtain more education. This conjecture is weakly supported as neither coefficient is significant.

Sampling Bias

Finally, it is necessary to determine whether there are any important sampling biases in the NBER-TH sample that would affect the school quality results. A comparison of the subsample used here with data from a comparable national sample indicates that there is no sampling problem (see Appendix).

[5] COLLEGE QUALITY MODELS

Up to this point only the effects of primary and secondary school quality have been considered. The quantity, in terms of the number of years of post-secondary education attained, but not the quality of college education has been taken into account. Although the models estimated indicated little evidence of any direct effect of school quality on the quantity of post-secondary education (years of schooling), it does not follow that the same relationship holds for the quality of post-secondary education. In fact, one hypothesis is that school quality has a primarily indirect effect on earnings through its effect on the quantity and quality of further schooling investments. It is this latter hypothesis which will be tested with two additional model specifications.

In Model II, post-secondary schooling investments are separated into two components representing indirect and direct investment costs. The first component is time spent in further schooling and the second, expenditures on further schooling. (There is, of course, no need to examine the amount of time spent in precollege schooling because it is a uniform twelve years for all respondents.) The two components of college investment could be combined, but there is considerable evidence (see Wachtel 1975b) that they are not homogeneous expenditures. Thus, the model has two post-secondary schooling variables, *S* and *QC*, the latter denoting direct college expenditures. *QC* is defined as expenditures per full-time-equivalent student[26] summed over the number of years spent in college. *S* and *QC* are not perfectly correlated because most respondents attended different graduate and undergraduate schools (the correlation is 0.84); however, the joint determination of *S* and *QC* violates the conditions for OLS estimation of the recursive system. Nevertheless, the model estimates are of interest as a basis for comparing the effects of school and college expenditures per pupil.[27]

The specification of Model II is as follows:

TABLE 6 Regression Estimates for Model II (figures in parentheses are standard errors of the coefficients)

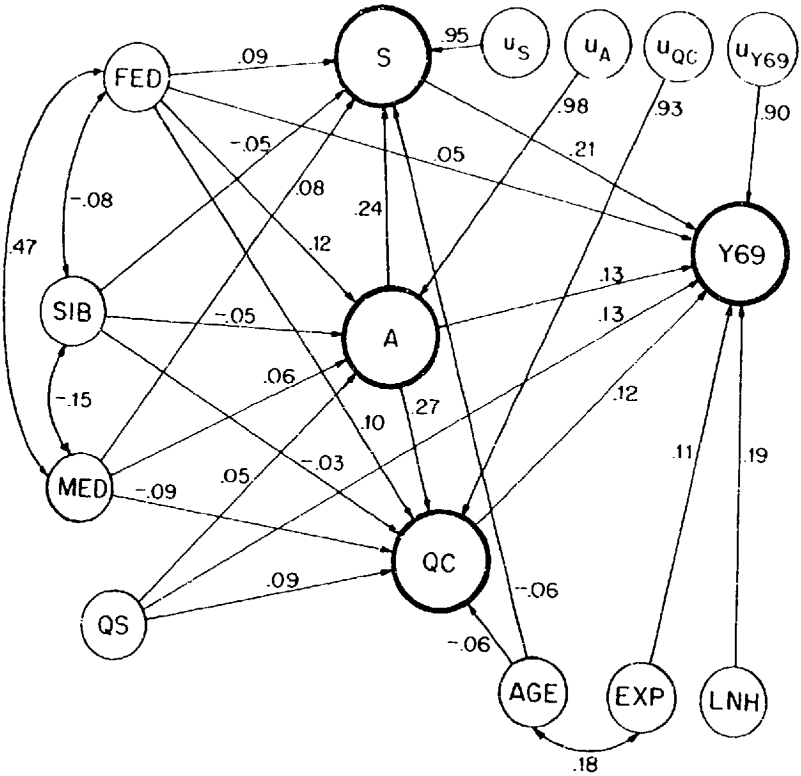
	QC	Y69
Constant	4.691	−0.3976
SIB	−0.0988 (0.0664)	
MED	0.1185 (0.0345)	
FED	0.1211 (0.0304)	0.0065 (0.0027)
AGE	−0.0672 (0.0244)	
EXP		0.0074 (0.0016)
LNH		0.4974 (0.0553)
QS	11.360 (2.927)	1.6995 (0.2873)
QC		0.0126 (0.0040)
A	0.6934 (0.0566)	0.0340 (0.0057)
S		0.0422 (0.0082)
R^2	0.1323	0.1981

NOTE: Variable definitions are given in Table 1. Sample size is 1,812.

$$A = \alpha_0 + \alpha_1 SIB + \alpha_2 MED + \alpha_3 FED + \alpha_4 QS + U_A$$
$$S = \beta_0 + \beta_1 SIB + \beta_2 MED + \beta_3 FED + \beta_4 AGE + \beta_5 A + U_S$$
$$QC = \gamma_0 + \gamma_1 SIB + \gamma_2 MED + \gamma_3 FED + \gamma_4 AGE + \gamma_5 QS + \gamma_6 A + U_{QC}$$
$$Y69 = \delta_0 + \delta_1 FED + \delta_2 EXP + \delta_3 LNH + \delta_4 QS + \delta_5 QC + \delta_6 A + \delta_7 S + U_{Y69}$$

Estimates of the *A* and *S* equations are shown in Table 2, columns 2 and 4, and the *QC* and *Y69* equations are shown in Table 6. The path diagram for the model is in Figure 2.

FIGURE 2 Path Diagram for Model II



Some explanation of the least satisfactory aspect of the results for Model I, the absence of school quality effects on the level of schooling attainment, is found in Model II. Although *QS* had no effect on the indirect component of college investments, it did have a strong effect on the direct component. Students from high-quality schools attend colleges with high expenditure levels; the higher the expenditure level, the higher, presumably, the level of quality of the college, that is, school quality has a strong and significant effect on the quality-corrected level of college attainment even if it does not affect the amount of time spent in college.[28] The earnings function in Model II also reveals that both school and college expenditure levels have strong effects on earnings in 1969. The introduction of *QC* into the equation reduces the *QS* coefficient by only 8 percent.

The coefficients of *QC* and *QS* in the earnings function can be used to calculate returns on school and college expenditures. Using the procedure outlined in the discussion of the Model I estimates, the *QS* coefficient of 1.6995 implies a rate of return of about 12.2 percent. A similar calculation can be made for the rate of return to direct college expenditures.

Several adjustments are necessary because *QC* sums expenditures over years of college. In order to calculate the return for a respondent with a four-year college education the estimated coefficient (0.0126) is multiplied by the ratio of average total college expenditures to average college years to obtain the annual expenditure effect; it is then multiplied by 4. Next, using the CPI, the coefficient is adjusted to the level of 1958 dollars rather than thousands of 1962–1963 dollars. The rate of return (R) for a respondent with four years of college is calculated from the following:

$$\text{(3)} \quad \sum_{i=21}^{24} \frac{\Delta C_i}{(1+R)^{i-16}} = \sum_{i=18}^{65} \frac{\Delta E_i}{(1+R)^{i-16}}$$

where ΔC and ΔE are college cost and earnings increments, respectively. The left-hand side of (3) represents the present value of costs at age 16 and the right-hand side, the present value of earnings. Using the same assumptions discussed earlier, (3) can be rewritten as: $PVC(R) = 0.00007547$ $PVE(R)$. $R = 12.5$ percent using Lillard's estimates of the present value of earnings.

Elsewhere in this issue, Solmon extensively discusses the importance of college quality in determining earnings, using the same data. He finds that a number of alternative factors other than expenditures also affect earnings. Included in his study is a subjective measure of school quality known as the Gourman rating. In model III, I use the overall Gourman rating, QG, of the undergraduate school attended as a measure of college quality. The recursive structure is reimposed in this model because QG is a determinant of total college years.[29] The model is restricted to the 1,437 respondents in the sample who attended college, or 78 percent of the total sample; the sample is reduced because it would be incorrect to assume a value of zero for the Gourman index for those who never attended college.

The specification of Model III is as follows:

$$A = \alpha_0 + \alpha_1 SIB + \alpha_2 MED + \alpha_3 FED + \alpha_4 QS + U_A$$

$$QG = \beta_0 + \beta_1 FED + \beta_2 QS + \beta_3 A + U_{QG}$$

$$S = \gamma_0 + \gamma_1 FED + \gamma_2 QG + \gamma_3 A + U_S$$

$$Y = \delta_0 + \delta_1 FED + \delta_2 EXP + \delta_3 LNH + \delta_4 QS + \delta_5 QG + \delta_6 A + \delta_7 S + U_Y$$

Primarily for empirical reasons, the specification is changed somewhat from that used previously. Several of the exogenous background variables, SIB, MED, and AGE, do not enter the attainment equation significantly in the subsample that excludes those who did not go to college. Regression estimates of Model III are found in Table 7, and the path diagram is in Figure 3.

The Gourman index has a significant effect on S and Y. School quality as measured by current expenditures per student is a significant determinant of A, QG, and Y. There is no direct effect of school quality on the attainment level, but there are indirect paths through both A and QG.

TABLE 7 Regression Estimates for Model III (figures in parentheses are standard errors of the coefficients)

	A	*QG*	*S*	*Y69*
Constant	−0.5979	395.1	15.161	−0.6321
SIB	−0.0849 (0.0314)			
MED	0.0229 (0.0157)			
FED	0.0507 (0.0138)	3.250 (0.779)	0.0126 (0.0131)	0.0055 (0.0030)
EXP				0.0091 (0.0018)
LNH				0.4842 (0.0624)
QS	3.774 (1.357)	494.4 (85.3)		1.5923 (0.3240)
QG			0.0012 (0.0004)	0.0004 (0.0001)
A		10.51 (1.66)	0.1999 (0.0288)	0.0337 (0.0064)
S				0.0526 (0.0063)
R^2	0.0288	0.0665	0.0480	0.1636

NOTE: Variable definitions are given in Table 1. Sample size is 1,437.

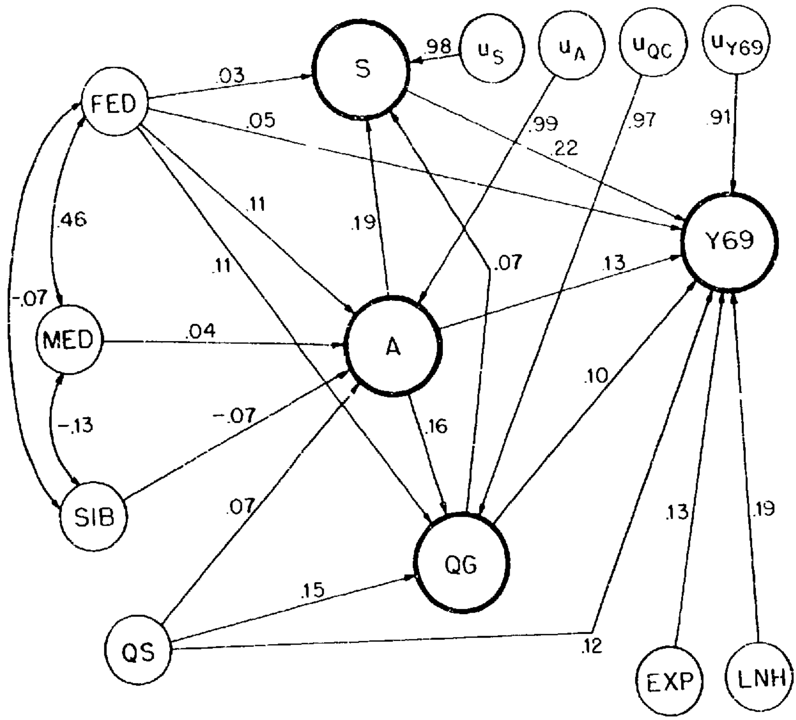
Thus, the school quality effect on attainment levels can be written as:

$$\frac{dS}{dQS} = \frac{\partial S}{\partial A}\frac{dA}{dQS} + \frac{\partial S}{\partial QG}\frac{dQG}{dQS} = 0.1999(3.774) + 0.0012(494.4) = 1.348$$

However, the effect is still small. A doubling of school expenditures will lead to an increase in attainment of about 14 percent of a year. The indirect effects of school quality on earnings, through *QG* and *A*, are fairly large. They amount to almost 25 percent of the direct effect. The combined effects of the quality variables, *QG* and *QS*, on earnings are substantial.

In summary, models II and III suggest that school quality at both the college and school level is an important determinant of earnings. Furthermore, the indirect effects of school quality through achievement and the quality of post-secondary schooling are substantial. School quality is a determinant of the quality of college attended, but has an independent effect on earnings as well.

FIGURE 3 **Path Diagram for Model III**



[6] FURTHER TESTS OF THE EARNINGS FUNCTION

Models I, II, and III estimate school quality effects on earnings at one point in time, using the 1969 earnings of a sample that is relatively homogeneous with respect to age. The NBER-TH respondents were probably near the peak level of their earnings capacity in 1969 (their mean age was 47). The obvious questions that arise are whether school quality effects are as strong at other points in the life cycle and whether quality affects the rate of growth of earnings over the life cycle. Additional information for answering these questions is available in the virtually complete earnings data for 1955 in the original Thorndike-Hagen survey.[30]

In order to investigate the effect of QS on earnings at an earlier point in the life cycle and on the rate of growth of earnings, two additional equations are estimated. The first is a Y55 earnings function similar to the equations shown earlier for Y69, and the second is a Y69 function with Y55 included as an explanatory variable. Regression estimates for these equations are shown in Table 8. The measure of school quality used in these results is again current expenditures per student in average daily attendance. All the symbols are defined as previously, with year subscripts added.[31]

The 1955 earnings function shows that school quality had a smaller

TABLE 8 Additional Earnings Functions (figures in parentheses are standard errors of the coefficients)

	Y55	Y69
Constant	1.1860	−0.8932
SIB	−0.0098	
	(0.0051)	
MED	0.0064	
	(0.0026)	
FED	0.0035	
	(0.0023)	
EXP55	0.0125	
	(0.0017)	
EXP69		0.0017
		(0.0013)
LNH		0.3197
		(0.0459)
QS	0.8638	1.1751
	(0.2225)	(0.2344)
A	0.0247	0.0185
	(0.0043)	(0.0047)
Y55		0.7352
		(0.0247)
S55	0.0345	
	(0.0043)	
S69		0.0442
		(0.0041)
R^2	0.0957	0.4565

NOTE: Variable definitions are given in Table 1. Sample size is 1,812.

proportional effect on earnings in 1955 than in 1969. Compare the coefficient of *QS* on *Y69* in Table 2, equation 6 (1.8377), with its coefficient on *Y55* in Table 8 (0.8638). Thus, there is evidence that school quality affects the rate of growth of earnings. This is also confirmed by the *Y69* equation shown in Table 8, where *Y55* is included. With *Y55* in the equation, the *QS* and *S69* coefficients are reduced by about one-third, while the *A* coefficient is reduced by half. School quality has a strong effect on earnings even when earlier earnings are held constant. This may indicate that the larger a respondent's human capital investments in schooling are, the greater will be his investment in on-the-job training. The background variables do not affect the growth in earnings; they do not enter the Y69 equation significantly.

Some limited data on the quality of individual high schools has been collected by the National Research Council in conjunction with the National Science Foundation Registry of Doctorate Holders. The NRC surveyed schools whose graduates had received Ph.D.'s and about 500 of the NBER-TH respondents could be matched with these schools.[32] Results using the NRC quality data were very similar to those obtained with the OE data: various measures of school quality had no effect on attainment levels and small effects on achievement and earnings. The school quality measures and their coefficients in an earnings function are summarized in Table 9. The specification is:

$$Y69 = \alpha_0 + \alpha_1 FED + \alpha_2 EXP + \alpha_3 LNH + \alpha_4 A + \alpha_5 S + \alpha_6 QN$$

where QN stands for the various quality measures based on the NRC data. The sample sizes differ because not all data were available for each high school. Per pupil cost figures were also provided by the school principals but did not enter the earnings function significantly.[33]

The class size variable can be interpreted as a scale effect. The result suggests that students from high schools with 1,000 students in their graduating classes (the mean size of the graduating class is 240) earn 12.9 percent more than students from an average-sized high school. Table 4 shows the earnings effect of average enrollment per building using OE data. With these data, a similar enrollment increase, i.e., 3.7 times the standard deviation, yields a 22.7 percent earnings increase. Thus, the

TABLE 9 Quality Effects on Earnings Based on National Research Council Data (figures in brackets are beta coefficients; figures in parentheses are standard deviations)

Quality Variable	Coefficient	Mean	Sample Size
Size of high school graduating class	0.00017* [0.08]	240.1 (206.1)	1,077
Percent of teachers with more than bachelor's degree	0.0023* [0.12]	32.1 (23.9)	672
Number of Ph.D's who graduated from high school as percent of graduating class	1.0136* [0.09]	0.035 (0.042)	1,414

*Coefficient is more than twice its standard error.

TABLE 10 Extended 1969 Earnings Function

	Predicted Deviation from Mean Earnings (dollars)	Percent of Sample
Education level		
H.S. education	−2,247	16.1
Vocational training	−2,044	7.8
Some college	−946	25.1
Undergraduate degree	1,190	28.8
Some graduate	648	5.5
Masters or more	1,560	9.3
Doctoral or professional degree	3,247	7.4
Ocupational group		
Blue collar	−3,085	10.9
Service worker	−4,318	2.9
Salesman	−1,073	6.9
Office worker	−4,721	1.7
Technical worker	−1,982	4.9
Salaried professional	−2,698	16.6
Self-employed professional	2,518	6.5
Manager	1,099	33.2
Business proprietor	3,861	16.4
Atypical employment		
Lawyer	2,377	3.3
M.D. or dentist	7,794	1.5
Teacher	−1,327	5.8
Unemployed 3 or more times	−1,665	4.5
Ability Groups		
(1) highest	1,135	21.5
(2)	159	26.0
(3)	−311	30.0
(4) lowest	−688	22.5
Religion		
Catholic	110	20.4
Jewish	4,363	5.3
Protestant and other	−338	74.3
Socioeconomic background		
Father teacher	17	1.2
Father business proprietor	205	28.6
Father occupational status high	298	16.0
Father's education ≥ 12 years	523	38.8
Mother's education ≥ 12 years	205	38.5
Grew up in rural area	−513	12.4
Went to H.S. in south	195	17.6
Took vocational course in H.S.	−45	13.7

TABLE 10 (concluded)

	Regression Coefficient	Mean
Continuous variables		
Work experience in years	60.3	21.4
Current school expenditures per student in average daily attendance[a] (dollars)	14.11	91.8
R^2 = 0.2775		
Standard error = 6,975		
Sample size = 4,170		
Mean earnings in real (1958) dollars = 12,613		

[a]Based on state averages for urban and rural areas.

results obtained from both data sets suggest that the scale effects can be substantial.

Similarly, the other quality variables also have large effects on earnings: an increase of one standard deviation in the proportion of teachers with more than a bachelor's degree is associated with a 5.5 percent earnings differential. The ratio of the number of graduates who obtained doctorates to the class size can be viewed as a peer effect. If the ratio increases by one standard deviation, expected earnings increase by 4.3 percent. These very rough results using school-specific data suggest that a more detailed study of school inputs would be useful.

As I noted earlier I have purposely kept the model specifications simple. This facilitates interpretation of the interrelationships but does not preclude the possibility that the various measures of school quality are correlated with other (omitted) determinants of earnings. To pursue the issue one step further, the statewide school quality measures were used in an ad hoc earnings function comprising a whole range of additional variables that represent socioeconomic background and current status and could affect earnings.

The specification of such a function without any measures of school quality has been studied by Taubman and Wales (1973) and Taubman (1973). Their extensive analyses of the determinants of earnings in the NBER-TH data were used to specify an extensive set of variables for an earnings function.[34] In addition, most of the variables were entered as a series of dummies so as to allow for nonlinearities in the estimated relationships. Results are shown in Table 10 for an extended earnings function that includes a school quality variable. R^2 is 0.2775 and falls to 0.2759 if the school expenditure variable is excluded.[35] A few of the coefficients (religion, father a teacher, and the two regional variables) are changed by as much as 20 percent when the school quality variable is

TABLE 11 Correlations Among Variables Using Jencks and NBER-TH Data

	FED	*A*	*S*	*Y**	*Y*	*QS*
			Jencks Data			
FED	1					
A	.345	1				
S	.426	.680	1			
*Y**	.214	.349	.353	1		
			NBER-TH Data			
FED	1					
A	.143	1				
S	.183	.245	1			
*Y**	.118	.159	.229	1		
Y	.137	.300	.300	.911	1	
QS	−.019	.067	.010	.095	.117	1

SOURCE: See accompanying text.

added, but most of them were insignificant to begin with. The school quality coefficient is more than three times its standard error, a finding which firmly supports the hypothesis that a school quality effect is present. Its beta coefficient is 0.05, which is only a third of that for a similar variable in Model I. This difference is about half due to the aggregation of the quality variable to state average data and about half due to the extension of the earnings function to include a broader set of variables.

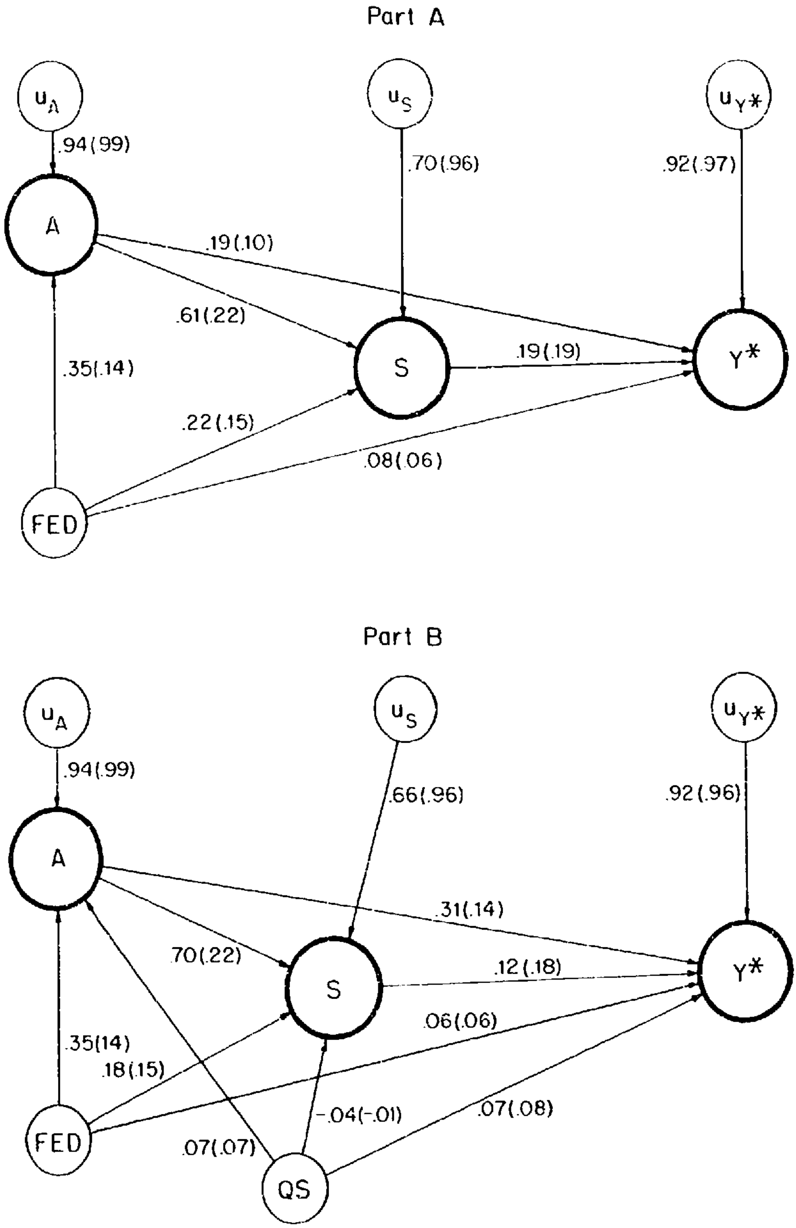
[7] SUMMARY AND CONCLUSIONS

The extensive economic literature on the contribution of schooling has tended to emphasize quantity, that is, schooling attainment, rather than quality, largely because data on quality are unavailable. This compromise is clearly unsatisfactory if earnings function estimates are going to be used in evaluating human capital investments. Even though the estimates of the returns to quality presented here are tentative and often imprecise, it has been shown that the contribution of quality differences at both the college and school level cannot be disregarded: (1) school quality significantly affects earnings both directly and indirectly through achievement; (2) school quality significantly affects college quality, although it does not affect the number of years of college attended; and (3) school quality alters the rate of growth of earnings over the life cycle.

APPENDIX: BIAS IN THE NBER-TH SAMPLE

The NBER-TH sample is in many respects atypical. It is therefore impossible to judge whether the results presented could be replicated with other data sets. Except for the few studies of school expenditures and earnings

FIGURE 4 **Path Diagrams for Simplified Models Comparing Jencks and NBER-TH Data**



NOTE: Path coefficients in parentheses are based on NBER-TH data correlations shown in bottom part of Table 11. The other set is based on Jencks's correlations, shown in the upper part of Table 11. For Part B, QS correlations from the NBER-TH data are used for both sets.

noted earlier there is no literature with which to compare the model estimates. However, we can compare the model to a similarly specified one based on national samples but without the QS variable. A simplified version of Model I, estimated from data from Jencks (1972, App. B) is in surprising agreement with the results based on the NBER-TH survey.

In Table 11 simple correlations taken from Jencks are shown in the upper part. The data are mostly from the 1962 Current Population Survey and refer to white, nonfarm men between the ages of 25 and 64. All the variables have been previously defined, except that here *A* stands for IQ and Y* is the level of income. In the lower part, correlations are shown that are based on the NBER-TH data, using all available data for each pairwise correlation. There are, of course, some large differences in the correlations because the range of ages and ability covered in NBER-TH sample is narrower than in Jencks's. Part A of Figure 4 shows a simplified path model that excludes the school quality variables. The path coefficients based on the NBER-TH correlations in Table 11 are in parentheses next to those based on Jencks's data in the same table. As expected, the relationships estimated from the NBER-TH data are not as strong, although their general nature is similar. It is also interesting to note that the residual effects are very large in both data sets. The comparison is unchanged when the quality variable is added to the model, as may be seen in part B of the figure, where correlations with *QS* from the NBER-TH data are used for both sets of calculations.

NOTES

1. This observation has been made by others; see Bowles (1970) and Hanushek (1972).
2. The data have been examined extensively by various researchers at the National Bureau, particularly in regard to the determinants of earnings, the distribution of earnings, the returns to schooling, and the schooling-ability interaction (see Juster 1975, Taubman and Wales 1973, Lillard 1973).
3. About 80 percent of the replies could be matched with statewide data on schools and with separate data for the urban and rural areas of each state.
4. The factor analysis was performed by Albert Beaton of the Educational Testing Service. The resulting test score is considered as either an ability (intelligence) or general achievement score. It is not clear that the two can be distinguished or that IQ tests measure intelligence and not achievement (see Bowles 1970, p. 26).
5. See Leibowitz (1974a) and Hill and Stafford (1974) for a discussion of home-related human capital investment.
6. There are other background variables (e.g., religion) that would enter the model significantly but are omitted in order to maintain the emphasis on school quality. In section 6, I present an extended earnings function which includes some of these.
7. There is some controversy over the existence of this interaction between schooling and ability. See Hause (1972) and Wachtel (1973).
8. Similar background variables are included in some discussion in the sociology literature of the determinants of educational attainment. See, for example, Sewell and Hauser (1972).

9. Chiswick and Mincer (1972) use weeks worked for the same reason. The sample used here excludes those with annual earnings of less than \$5,000, thus reducing variation in weeks worked. The hours variable is consistently much stronger than the weeks worked variable, although the log of weeks worked would also enter the earnings function significantly. It is excluded so as not to "clutter" the equation with multicollinear explanatory variables. The school quality results are unaffected in either case.
   Hours worked is taken to be exogenous. The simultaneity of hours and earnings is ignored in order to maintain the simplicity of the recursive model.
10. A difficulty with the earnings function approach is that these variables are used as proxies for the amount of human capital although they are more accurately an index of inputs into human capital production (see Leibowtiz 1974b).
11. The percentage shares of the total sample that satisfy each of the elimination criteria are: airplane pilots, 1.3; unmarried, 2.3; poor health, 0.7; real 1969 earnings below \$5,000, 1.3; real 1969 earnings above \$75,000, 1.9; real 1955 earnings below \$4,000, 6.1; real 1955 earnings above \$75,000, 7.8; *QS* unavailable, 54.1; and attended nonpublic school, 5.9. The eliminations based on the 1955 earnings information are very large because of missing and erroneous data.
12. Although costs at the primary and secondary level do differ, I was not able to make an adjustment for differences in the composition of the student body because there was wide variation in the definition of secondary schools.
13. That result might be peculiar to this sample, which is restricted to individuals with at least a twelfth grade education. The respondents' investment choices for further education are also in many ways atypical because of the military experience that intervened in their lives. However, results not reported show no evidence of school quality effects on the decision to go to college. In a similar equation with aggregate data, Johnson and Stafford (1973) report a significant expenditure effect on attainment. Their results indicate that attainment increases by six-tenths of a year when school expenditures double.
14. *MED* and *FED* regression coefficients, with standard errors in parentheses and beta coefficients in brackets, from equations 2 (ability) and 4 (schooling attainment) in Table 2 re-estimated with 779 respondents with complete data are as follows:

	FED	*MED*
Table 2(2) *A*	.0292	.0730
	(.0196)	(.0209)
	[.06]	[.14]
Table 2(4) *S*	.0253	.0667
	(.0238)	(.0255)
	[.04]	[.11]

   The other coefficients are not appreciably affected by the re-estimation.
15. See Duncan (1966) for an explanation of path analysis. The path coefficients, including the residual paths, can be calculated from the basic theorem of path analysis:

$$\gamma_{ij} = \Sigma_q P_{iq} \gamma_{jq}$$

   where i and j are variables in the recursive model. γ_{ij} is the correlation, q is the subset of variables in the equation for the ith variable, and P_{iq} is the path from q to i.
16. There are, as well, more fundamental objections to the analysis. Implicit in the discussion relating school quality to school expenditures is the assumption that schools operate at the frontier of their production possibilities curve. This need not be the case. Therefore, increased expenditures will not necessarily lead to improvements in the quality of schooling. Definitive answers can only be obtained in an experimental context for which data are not available.

17. The use of this figure will give an upper bound for the return, since later estimates of a 1955 earnings function show a much smaller coefficient.
18. Lillard (1973, Table B2); Lillard made available extensions of this table.
19. This is expected, in part, because *QS* is a school district measure while *SY* is the statewide average. Therefore, the test was also performed with statewide data for per pupil school expenditures. In this case, school quality dominated *SY* completely in the earnings equation. It was significantly positive whereas *SY* had a small negative coefficient that was smaller than its standard error.
20. The transformation is based on this relationship:

$$\frac{dY69}{d(1/SY)} \frac{d(1/SY)}{dSY} = -0.1483$$

Therefore,

$$\frac{dY69}{d(1/SY)} = -0.1483 \div \frac{d(1/SY)}{dSY} = 0.1483\,(SY)^2$$

21. Since *SY* is a statewide median, the relative expenditure effect may represent the influence of city size or the degree of urbanization. This issue will be examined later.
22. None of the other studies of school quality effects on earnings report any results with other quality measures, although the data are available from the same sources as the expenditure data.
23. These results represent extrapolations well beyond the observed sample range, and therefore I cannot be very confident about their accuracy.
24. In addition, the interaction of school expenditures and the attainment level is discussed in Wachtel (1975a).
25. All the NBER-TH respondents are in the top half of the populationwide intelligence distribution.
26. College expenditures were obtained from the Office of Education and matched with the respondents' reports of schools attended. Median expenditures were used when data were missing.
27. The entire sample of 1,812 was used. *QC*, the college investment expenditure variable, was zero for those with no post-secondary schooling.
28. This dichotomy need not be bothersome. If we view time spent in college as an index of consumption benefits, then there need not be any relationship between *S* and *QS*.
29. One problem remains in the recursive structure of all models. A small number of respondents completed all or part of their college education prior to taking the army tests that determined achievement score, *A*. To some extent, then, *A* is not prior to *S* and *QC* in the recursive ordering.
30. Earnings in 1955, when the respondents were on average 33 years old, are particularly suitable for the analysis. By 1955, most schooling was completed as well as a long initial period of on-the-job training.
31. *LNH* does not appear in the *Y55* equation because hours worked was not collected at that time. *EXP55* and *EXP69* differ because a few respondents did not enter the labor force until after 1955.
32. Although the information is disaggregated to the school level, some of it is based on the recollections of the principal and is probably not very accurate. Lindsey Harmon of the NRC provided these data.
33. The data were obtained in 1964; the principals were asked to provide retrospective data going back over twenty years. Therefore, the cost data are highly unreliable, and so this result is not surprising.
34. Other variables that are likely candidates for inclusion in the extended earnings function

are mobility and current location. A peculiarity of this sample is that neither one is significantly related to earnings.

35. The sample size is 4,170. Respondents were eliminated from the sample if they were single, in poor health, or pilots or farmers; attended nonpublic high schools; had real 1969 earnings outside the $5,000 to $75,000 range; or if the state where they attended high school was unknown.

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