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AUTHOR	Young, Kan-Hua; Jamison, Dean T.
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ABSTRACT

To calculate the economic benefits of schooling and compensatory education, a statistical model estimated the effects of schooling and literacy on earnings and employment. The literacy measure was obtained for a probable sample of the U.S. population in 1972, from the National Reading Survey. The measure was administered with a background demographic questionnaire to 2,308 individuals, age 25 to 60, who reported some earnings in 1972. Variables examined were: 1972 earnings, wage rate, work hours, years of schooling, reading score, potential work experience, other income, father's education, mother's education, age, race, sex, and employment status. Three models were used: simple earnings function, labor market, and educational achievement. Methodologically, both recursive and simultaneous models were examined in both the labor market and the educational achievement analysis. In terms of increased annual earnings, estimated benefits of a hypothetical compulsory education for a representative individual are the highest for white males ($3,810) and the lowest for white females ($1,370). Corresponding benefits for black males and females are $2,580 and $1,940. Estimated benefits of a low target compensatory reading program for a representative individual are $323 and $273 for white males and black males, only $12 for white females, and negative for black females. (CP)

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THE ECONOMIC BENEFITS OF SCHOOLING AND READING COMPETENCE

Kan-Hua Young
and
Dean T. Jamison

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Abstract

The purpose of this paper is to ascertain what economic benefits would accrue to compensatory education programs that were effective in raising the schooling and literacy levels of individuals after they left school. To do this we use a generalized earnings function format to examine the effects of schooling and literacy on individual earnings. The literacy measure was obtained for a 1972 probability sample of the U.S. population, and was administered with a background questionnaire.

Empirical results were first obtained from simple earnings functions. These results were compared with results obtained from a more elaborate conceptual framework incorporating a labor market model and an educational achievement model. The results of the models based on this more refined framework were then used to evaluate the economic benefits of schooling and compensatory reading education in terms of both annual earnings and discounted lifetime earnings. Methodologically, in both labor market and educational achievement analyses, both recursive and simultaneous models have been examined. However, in both situations, problems of identification were encountered in implementing the simultaneous equation approach, and our final results are based on recursive models that appear to provide reasonable results.

CONTENTS

THE ECONOMIC BENEFITS OF SCHOOLING AND READING COMPETENCE

by

Kan-Hua Young and Dean T. Jamison *

Our purpose in this paper is to estimate a statistical model of the effects of schooling and literacy on earnings and employment that will allow us to calculate the economic benefits of schooling and compensatory education. Our approach is in the spirit of the earnings function literature, which has been recently and thoroughly reviewed by Psacharopoulos (1973), but our findings extend the existing literature in three important ways. First, our data are from a 1972 probability sample of the U.S. population over the age of 16; previous earnings functions have been for restricted subgroups of the population, usually white males, and our data therefore allow more detailed analysis of the effects of race and sex on earnings than has hitherto been possible within a single data set. Second, our data allow construction of a block-recursive model that examines first the interaction of education and reading skill and, second, the

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determinants of wage rate and labor supply. The economic benefits of schooling and literacy skills can thus be decomposed into not only their effects on each other, but also on wage rate and labor supply. Third, and most important, our data set includes a measure of each respondent's basic reading capability. The measure was carefully constructed to assess the respondent's capability to read the kind of material that appears frequently in day to day life in the contemporary United States; it thus differs in important ways from the ability measures that appear in a number of earnings functions. Perhaps its most important difference is that impartation of reading competence at this level is perhaps the foremost single objective stated by public school systems; and over the last decade there has been a massive national effort (funded under Title I of the Elementary and Secondary Education Act of 1965) directed toward providing compensatory reading education for those students who had failed to acquire the basic skills. Therefore, in terms of policy implications, perhaps the principal contribution of our paper is to provide a preliminary and necessarily tentative assessment of what the narrowly defined economic benefits would be of varying degrees of success in our nationwide efforts at compensatory reading education.

The paper is organized as follows: In Section I we describe our basic models and data, and in Section II we present results from analyzing our data by way of a standard earnings function. In Sections III and IV we estimate the block recursive models we actually use to estimate benefits; Section III deals with the labor market part of the model and Section IV deals with the schooling-literacy part of the model. In Section V we develop our methodology for computing total benefits, and, using the empirical results of Sections III and IV, compute the benefits of schooling and compensatory education programs. Appendices provide more information about our data, and additional results based on some alternative approaches that are mentioned only briefly in the main text.

I. Models and Data

In this section we describe first the basic models we consider for analyzing our data, then describe the data itself. Since we have no information on a number of the variables that would, ideally, appear in an analysis of this sort, we conclude this section by discussing some of those missing variables and the implications their absence has for our analysis.

Models. Figure 1 presents schematically the alternative block recursive models we considered. The exogenous variables -- sex, race, age and parents' education -- are assumed to determine schooling and literacy. We present, however, three alternative models for this process, which are labelled A, B, and C in Figure 1. Models A and B are strictly recursive; in Model A, schooling is assumed to determine literacy, and in Model B literacy determines schooling (on the assumption that continued success and willingness to stay in school is determined at least in part by reading competence). Model C is a simultaneous one, assuming literacy and schooling to be simultaneously determined.

Model C thus includes A and B as special cases and, were it not for the problem of identification, our analysis would focus on Model C. However, for a variety of reasons, discussed more fully in the course of the paper, Model A seemed most suitable for analyzing our data set; we thus use Model A in the text of the paper, and its results are described in Section IV. In Appendix D, though, we present two-stage least squares estimates of Model C to be used for comparison with Model A.

The next major box to the right in Figure 1 schematizes the labor market model. Again there is the problem of whether to develop a simultaneous or recursive model, and again there are three alternatives, which we label 1, 2, and 3, with the obvious interpretations. In accord with most studies of labor supply based on survey data we end up assuming wages to affect hours worked but not vice versa; our labor market results are thus based on Model 1, and our overall results on Model A-1. Estimation of Model 1 appears in Section III. We have again estimated the simultaneous model, Model 3, for comparison and the results of this estimation appear in Appendix C.

Since Models A and 1 are both recursive, the overall model we have chosen to estimate is strictly recursive greatly simplifying problems of identification and estimation. We are mindful of the potential distortions this particular specification may have, and discuss its specific advantages and disadvantages at a number of points in the paper. We also point out the direction of bias it could induce in estimating the relative benefits of schooling and compensatory reading education.

Variables and data. In recent years there has been a considerable literature examining the effects of education on earnings. Most of these studies, however, have been based on samples that are inadequate in one or more of the following aspects: small sample size, too specialized a sample from which to form generalizations, or inadequate measures of education and ability. In general, most studies have been concerned with urban white males. Only in recent years have studies on the earnings of blacks and women begun to be undertaken. For example, studies of earnings of blacks have been made by Weiss (1970) and Welch (1973), and studies of earnings of women may be found in Kreps (1971), Hoffer (1973), Woodhall (1973) and Mincer and Polachek (1973).

The sample data used in the present study, known as the National Reading Survey, were collected in 1973 for the U.S. Department of Health, Education, and Welfare through a contract to Educational Testing Service. There are several major advantages in using this sample in preference to the others. First, it is a national probability sample covering individuals of both men and women age 16 and over in all geographic areas. Second, in addition to the usual socioeconomic and other background variables which may determine earnings, data on educational level and reading competence are also available. The availability of reading competence data is, for reasons mentioned in the introductory paragraphs of the paper, especially important. Although the effects of some measures of ability, such as IQ scores and Air Force Qualifying Test scores, on the level of earnings have been studied, it is plausible that reading competence is more subject to the influence of schools, and that the study of its effects are, therefore, of greater policy relevance.[1] Third, our sample data refer to 1972 which is more recent than most of the data analyzed in recent literature, and thus deserve special attention. Finally, the sample contains information that allows us to estimate the labor market segment of the model of Figure 1.

The general survey design of the National Reading Survey was based on a probability sampling model, using households as basic sampling units. Everyone in the selected household, 16 years of age and older, was to be interviewed. The necessity of callbacks and persistence to achieve high completion rates was stressed; this resulted in an overall response rate of approximately 70%. The survey instruments for each respondent consisted of a brief demographic questionnaire and one of ten books each containing 17 reading tasks. Of the 7866 persons interviewed in the survey, 270 responded only to the demographic questionnaire because they were visually handicapped, unable to read the headlines in a newspaper, or simply refused to answer the reading tasks.[2]

The subsample used for the analysis reported in this paper is limited to individuals of age 25 to 60 who reported some earnings for 1972 and who are either white or black. Furthermore, individuals on whom information was incomplete were also eliminated from our subsample in order to avoid the problem of missing observations. As a result of introducing these restrictions, the actual subsample size used in this study becomes 2308 individuals. The means and standard deviations of variables in our total sample and in each of our four race-sex subsamples are presented in Table 1. Appendix A contains the correlation matrices for the total sample and each of the subsamples.

As can be seen from the table, in our sample approximately 6% of the respondents are black and 41% are women. The mean age is about 39. The data also clearly show that men earned considerably more than women as a result of working somewhat longer hours at considerably higher wage rates. Years of schooling and reading scores are generally lower for blacks, especially black males. Variables whose meanings are not self-explanatory in Table 1 are discussed further below.

Y: Earnings for 1972 reported by the individuals interviewed, measured in thousand dollars;

Y_1: Wage rate computed by dividing earnings by work hours ($Y_1 = Y \div Y_2$);

Y_2: Work hours, measured in thousands of hours worked during 1972 (full-time workers who worked all year around are assumed to work 2,000 hours);

X_2: Reading scores, measured by standardized scores on one of ten sets of 17 reading tasks administered at the time of the survey (the items were all designed to measure basic literacy, and thus provide discrimination only among those with low reading competence);

X_3: Potential work experience, measured by subtracting schooling plus 5 from age ($X_3 = X_7 - X_1 - 5$);

X_6: Other income, all family incomes other than those earned by the individual interviewed, measured in thousands of dollars;

X_7: Age of individual interviewed;

X_{10}: Employment status of the individual interviewed (full-time salaried workers = 0; self-employed and part-time workers = 1).

Missing variables. A number of variables that are plausibly important determinants of income were not available from the National Reading Survey, and their omission raises cautions in interpreting our results. Four of the most important categories of missing variables are parental income, school quality, personality attributes of the respondent, and occupation of the respondent. Bowles and Nelson (1974) mention results from a study by Hauser, Lutterman, and Sewell (1971) that indicate parents' income to affect adult status independent of their education. Sewell and Hauser (1972) report direct effects of father's occupation on son's occupation, and father's income on son's. Thus our inclusion of only parents' education as a proxy for SES clearly limits our analysis.

A second category of variable missing from our data set is some measure of school input quality. Early work on the effects of school quality measures, e.g., Welch (1966), concluded that there were important effects, but Welch had available only highly aggregated data from which to draw this conclusion. More recent analyses using recursively structured earnings functions -- Ribich and Murphy (n.d.), Wachtel (1974) -- also find positive effects; much of the effect is through the influence of quality measures on years of educational attainment. Both the Ribich and Murphy and the Wachtel samples provide information only for males; their samples are further specialized in that Ribich and Murphy have data only for very recent entrants to the labor market (Project Talent data) and Wachtel only for high ability individuals (NBER/Thorndike-Hagen data). Nevertheless, the positive findings for these limited samples suggests the potential value of examining school quality measures in a probability sample such as ours.

An important school of thought -- perhaps best presented in Gintis (1971) -- maintains that the observed high correlation between schocling and earnings results not from the cognitive effects of schooling but rather from its effects on personality variables. Gintis persuasively makes the case that even after controlling for certain measures of cognitive outcome, schooling has a strong independent effect on earnings. (Our own results, even though we show literacy to have an important positive effect on the earnings of white males, are consistent with this conclusion of Gintis's.) However, to our knowledge, there exist no earnings functions that include personality measures as independent variables, and our data set allows no exception in this respect.[3] To the extent that affective outcomes do constitute an important fraction of the link between schooling and earnings, our analysis must be regarded as seriously incomplete.

A fourth shortcoming of our data set was lack of adequate information on the respondents' occupations. Occupation is an important intervening variable between background and schooling on the one hand, and wages and labor force participation on the other; the nature of this linkage has been of particular concern to sociologists, e.g., Duncan, Featherman, and Duncan (1972). The absence of data on occupation is of particular importance in our study because the differing returns to literacy by race and sex may, we hypothesize, result from interaction effects of literacy and occupation on income. We discuss this possibility in more detail later.

Thus there is a range of important questions that our analysis will be unable to address, and lack of information on some of these missing variables suggests caution in interpreting our results. Yet in spite of these weaknesses, our data set has a number of unique features that make its analysis worthwhile; most important of these are that it was generated from a probability sample of the U.S. population; it includes a measure of individual literacy, and it allows simultaneous study of educational attainment and labor force participation. We turn now to our results.

II. Empirical Earnings Function

Recent economic literature inquiring into the effects of education on earnings has generally followed the work of Schultz (1963), Becker (196[illegible]), and Mincer (19[illegible]). Although most of these studies have been concerned with the rate of return to education in the United States, similar studies have also been made for many other countries; for a review see Psacharopoulos (1973). While the primary concern of the present study is not to estimate an empirical earnings function, we believe it worthwhile to present our earnings function for comparison with the existing literature. There are several important questions that we shall attempt to answer in our analysis of empirical earnings functions. Among these are the questions of whether the earnings functions differ for blacks and whites, or for males and females, and if so, in what way and to what extent they differ. In addition, we shall consider some more specific questions such as whether the returns to education are different for blacks and whites, or for males and females. Finally, and central to our study, we shall also be interested in the effects of reading competence on the level of individual earnings, and these effects vary by race and sex.

Most empirical earnings functions in the literature have either employed a semi-logarithmic or simple linear function, using years of schooling, work experience and other socioeconomic variables as the explanatory variables. Occasionally, squared variables (or other transformations) are also included as explanatory variables. In general, assuming quadratic specifications, the empirical earnings function is generally specified as one of the following two convenient forms:

$$\text{Ln } Y = \alpha_0 + \sum_{i=1}^{k} \alpha_i X_i + \sum_{i=1}^{k} \alpha_{i+k} X_i^2 + U \qquad (1)$$

or

$$Y = \beta_0 + \sum_{i=1}^{k} \beta_i X_i + \sum_{i=1}^{k} \beta_{i+k} X_i^2 + V \qquad (2)$$

where α's and β's are the parameters to be estimated (some of them may be restricted to zero), k is the number of linear explanatory variables, and U and V are error terms, generally assumed to have zero mean and finite variance. Using these specifications, and applying ordinary least squares for estimation, we have obtained the empirical earnings function as reported in Tables 2 and 3 where the results of semi-logarithmic and simple linear specifications are reported separately.[4]

Psacharopoulos (1973) found in his survey of earnings functions no consistent empirical support for eq. (1) over eq. (2), and the linear results can be more easily understood or interpreted. For this reason, both empirical earnings function of eqs. (1) and (2) are reported: However, strictly speaking, the choice between the log-linear specification (eq. 1) and the linear one (eq. 2) cannot be made simply by comparing goodness of statistical fit as represented by R^2's. Earlier Mincer (1958, 1972) has advanced a theoretical argument for using eq. (1). More recently, Heckman and Polachek (1974), employing a Box and Cox procedure, found eq. (1) to be empirically superior to eq. (2), using the 1960 and 1970 Census samples and the 1967 Survey of Economic Opportunity Data.

According to both Tables 2 and 3, years of schooling is clearly a significant factor affecting earnings. The effects of reading scores on earnings are significantly positive only for white males. Apparently the effects of reading competence on earnings for blacks, and to some extent for white females, are unimportant. One plausible explanation for the differing effects of reading scores across subgroups is that there is a strong interaction between the effects of occupation and literacy on earnings. Literacy may be helpful in some occupations but not in others, and white males might have preponderant access to the occupations in which it is useful. As our sample contains only poor information on the respondents' occupation, we cannot test this hypothesis. Nonetheless, if it were correct, it would suggest that improving reading scores for, say, black females might still have <u>potential</u> economic benefits; realization of this potential would depend on their having better access to the appropriate occupations.

The effects of work experience on earnings are generally positive and have a general tendency to decline as the number of years and work experience increases. The magnitudes of these effects, however, can be estimated reliably only for whites, especially white males. Although we expect our measure of potential work experience may be less satisfactory for females whose work experience is more likely to exhibit a discontinuous pattern, we did not anticipate the considerable difference in the effects of work experience for white and black males that our results indicate.[5] Both the effects of father's and mother's education on earnings seem to be unimportant for all subsamples.[6] In some instances, the estimated effects of mother's education are negative, and in the case of black females even statistically significant. The effects of work hours on earnings are clearly statistically very significant, especially for whites as compared with blacks. The effects of race and sex on earnings are clearly important, judging from the fact that the dummy variables in the regressions computed from total sample are statistically significant and the regressions of different subsamples seem to be quite different.[7] Finally, since most studies of earnings functions are related to the empirical estimation of the rate of return, we may point out that rough estimates of the rates of return, to schooling, according to an approach suggested by Mincer, are provided by the regression coefficients associated with the schooling variable in Table 2. Thus, the estimated rates of return to schooling are 7.7% and 8.7% for white males and females and 7.4% and 15.2% for black males and females respectively. Similar estimates may be derived from Table 3 by calculating $(\partial Y/\partial X_1)Y$ which also provides rough estimates of the rates of return to schooling.[8]

According to this approach, the rates of return to schooling (at the mean earnings) are 7.4% and 9.7% for white males and females and 9.0% and 12.4% for black males and females.[9] We must point out, however, that these rough estimates fail to adjust for possible effects of schooling on other explanatory variables, such as reading scores and work experience. We shall consider this issue more fully later in our discussion of the economic benefits of schooling and compensatory reading.

III. Labor Market Analysis: Wage Rate and Work Hours

The results of empirical earnings functions shown in Tables 2 and 3, while they provide interesting information, can be difficult to interpret for some purposes. This is in part because the effects of schooling and literacy on wage rate and work hours are intermingled in eqs. (1) and (2), and in part because of interdependence of schooling and literacy. In this section we analyze in more detail the structure of the labor market, and in the next section we deal with the interaction of schooling and literacy. To understand why the effects of schooling and literacy are intermingled, we must inquire into the meanings of the parameters α's and β's in eqs. (1) and (2). For simplicity, assuming eqs. (1) and (2) are strictly linear in explanatory variables, we can verify that

$$\alpha_i = \left(\frac{\partial \ln Y}{\partial X_i}\right) = \left(\frac{1}{Y_1}\right)\left(\frac{\partial Y_1}{\partial X_i}\right) + \left(\frac{1}{Y_2}\right)\left(\frac{\partial Y_2}{\partial X_i}\right)$$

$$= (Y/X_i) \rho_i (1 + \varepsilon)$$

$$\beta_i = \left(\frac{\partial Y}{\partial X_i}\right) = Y_2 \left(\frac{\partial Y_1}{\partial X_i}\right) + Y_1 \left(\frac{\partial Y_2}{\partial X_i}\right)$$

and $$= (1/X_i) \rho_i (1 + \varepsilon)$$

where $\rho_i = \left(\frac{X_i}{Y_1}\right)\left(\frac{\partial Y_1}{\partial X_i}\right)$ and $\varepsilon = \left(\frac{\partial Y_2}{\partial Y_1}\right)\left(\frac{Y_1}{Y_2}\right)$

are the elasticity of wage rate with respect to X_i and the elasticity of work hours with respect to wage rate (elasticity of labor supply?). Clearly the parameters α's and β's reflect not only the direct effect of an exogenous variable on wage rate, but also its indirect effect on work hours through wage rate. In this section we shall, therefore, analyze the effects of various factors on wage rate and work hours by estimating wage determination function and work hours function separately. Ideally, an analysis of labor market should consider both demand and supply factors simultaneously, and one way of formulating such a model is to consider the wage determination function as the inverse demand function for labor and the work hours function as the supply function of labor.[10] Conceptually the wage determination function and the work hours function can, therefore, be regarded as a system of two simultaneous equations, where Y_1 and Y_2 are the two endogenous variables. In formal notation, using linear specifications, the wage determination function and the work hours function can be written as

$$Y_1 = \gamma_0 + \Sigma \gamma_i X_i + \gamma Y_2 + U \tag{3}$$

and

$$Y_2 = \delta_0 + \Sigma \delta_i X_i + \delta Y_1 + V \tag{4}$$

where γ's and δ's are the parameters to be estimated, and U and V are error terms.[11] For identification purpose, some of the parameters γ's and δ's must be restricted to be zero. The model as is formulated is a simultaneous model because neither $\gamma=0$ nor $\delta=0$ is necessarily imposed. One version of the simultaneous model has been estimated by both the Ordinary Least Squares (OLS) and the Two-Stage Least Squares(TSLS) procedures. The TSLS estimates, however, have been obtained only with an additional restriction in order to avoid a singular matrix in the second stage of computation. For this reason, in the following text only the results of a recursive model (assuming $\gamma=0$ and $\delta\neq0$) will be examined, and the results of a simultaneous model ($\gamma\neq0$ and $\delta\neq0$) are presented in Appendix C. Notice that while in the simultaneous model we assume wage rate affects work hours and vice versa; in the recursive model we assume wage rate affects work hours but not vice versa.[12]

The empirical results of wage determination function and the work hours function of the recursive model are presented in Tables 4 and 5. Since the model is specified as recursive, the OLS is an appropriate estimation procedure, and there is no need to employ the TSLS or any other estimation procedure designed for estimating the parameters of a system of simultaneous equations.

The empirical results of Tables 4 and 5 show that R^2's of both the wage determination function and work hours function are considerably lower than what were obtained for the earnings functions. Nevertheless, some of the individual coefficients are statistically highly significant, especially in the wage determination function and work hours function of white males. In general, schooling appears to be a significant factor in determining wage rates for all subsamples, and is also a significant factor in determining work hours of both white males and white females. The effects of reading scores on wage rate and work hours are generally insignificant, except for a negative effect on work hours for black females. There is some evidence indicating that reading scores probably have a slight effect on wage rate of white males and that its effects on work hours are positive for male workers but negative for female workers. The effects of work experience on wage rate and work hours appear to be more significant for whites than blacks, especially for white males. In general, wage rate appears to increase with work experience but at a smaller rate as experience increases, except for black females. Less experienced white males tend to work for longer hours than more experienced white males. The same is perhaps true for black females. A similar pattern, however, is not indicated for white females or black males.

The effects of father's education and mother's education on wage rate and work hours appear to be quite different for different subsamples. In general, the effects of father's and mother's education on wage rate are negative for white males, perhaps indicating a willingness to trade off income for status.[13] The effect of mother's education on wage rate is negative for blacks, especially for females. The effects of father's and mother's education on work hours are generally positive, though they are usually not statistically significant except the effects of father's education for blacks. The effects of father's education on work hours for white females are negative and almost statistically significant, a result whose interpretation does not seem to be apparent. The effect of other income on work hours, which corresponds roughly with the effect of wife's income and husband's income for males and females respectively, is statistically significant only for whites. Nevertheless the empirical results clearly indicate that such an effect is negative, as would be expected, for the work hours of female workers or the labor supply of married women. However, the effect of wage rate on work hours is negative for all subsamples, though only the coefficients for white males and females are statistically significant, implying a strong possibility of backward-bending labor supply curves. Finally, the effects of race and sex on wage rate and work hours are generally significant statistically, though the dummy variable for race is not significant in the work hours function computed from the total sample.

IV. Determinants of Educational Achievements: Years of Schooling and Reading Competence

In the previous section the effects of schooling and reading scores on both wage rate and work hours have been analyzed along with other background variables such as father's and mother's education as well as race and sex. The purpose of this section is to inquire further into the determinants of years of schooling and reading competence; both may be regarded as alternative measures of educational achievement. Although conceptually the production function approach, which has been increasingly applied to educational processes, may be useful, because of the lack of school quality measures in our data, no attempt has been made to follow this approach in the following analysis. Our major concerns in this section are simply to determine what are the significant factors that may affect years of schooling and reading competence. In particular, we shall also be concerned with the questions of whether reading competence may be determined by years of schooling, and possibly, though perhaps unlikely in the present sample, vice versa.

In a general form, the educational achievement model may be specified as

$$X_1 = \lambda_o + \Sigma_{i=3}^{k} \lambda_i X_i + \lambda X_2 + U \qquad (5)$$

$$X_2 = \mu_o + \Sigma_{i=3}^{k} \mu_i X_i + \mu X_1 + V, \qquad (6)$$

where X_1 and X_2 are years of schooling and reading scores, λ's and μ's are the parameters to be estimated, and i includes a given set of age and other background variables. The educational achievement model as specified above is a two-equation simultaneous model. As it stands, the schooling equation and the reading equation are not identified.

Therefore, some additional restrictions on the parameters λ's and μ's must be imposed. A particular approach that has been employed in the present study for identification purpose is to restrict the parameters associated with father's education and mother's education in the schooling function to be the same, and also to restrict the parameters of father's education for the whites and mother's education for the blacks in the reading equation to be zero. These restrictions are somewhat arbitrary and are based mainly on judgments derived from the preliminary empirical results. For this reason the empirical results of the simultaneous model of educational achievements will not be discussed here. They are presented, however, in Appendix D, because some of its results are interesting, despite the possible shortcomings of the identification procedure.

Rather than examining the empirical results of the simultaneous model (assuming $\lambda \neq 0$ and $\mu \neq 0$), the following discussion will be limited to those of the recursive model (assuming $\lambda = 0$ and $\mu \neq 0$) that implies schooling affects reading but not vice versa. This recursive model is not unreasonable, since our reading scores are measures of reading competence taken after individuals left their schools. Carnoy (1972) suggested another type of recursive model, which implies reading (or other measures of ability) affects schooling but not vice versa. This type of recursive model, as is supported by our preliminary empirical evidence, is less suitable for our sample.

The actual explanatory variables included in eqs. (5) and (6) are father's education, mother's education, age, race and sex.[14] Notice that reading scores is not included in eq. (5) but schooling is included in eq. (6)

in the recursive model to be discussed. Because the selected educational achievement model is recursive, OLS can be applied to estimate the parameters of eqs. (5) and (6). It must be mentioned that we have treated the estimation of eqs. (5) and (6) separately from that of eqs. (3) and (4), partly because of our belief in the blockwise recursive nature of our specified models and partly because several difficulties were encountered in the simultaneous estimation of our labor market and educational achievement models as was explained earlier. In any event, since the selected labor market and educational achievement models are both recursive, the OLS procedure can be appropriately applied to estimate the parameters of each equation separately.

The empirical results of the recursive educational achievement model (assuming $\lambda = 0$) are presented in Tables 6 and 7 for the determinants of schooling and reading scores respectively. In general goodness-of-fits as represented by R^2's are reasonable. Most of the individual coefficients are statistically significant. The effect of age on schooling is statistically significantly negative for both black and white males, with numerical magnitude for black males considerably larger than that of white males (in absolute values), reflecting the fact that the average increase of educational level perhaps has been the fastest for black males. The effect of age on reading scores, however, indicates a somewhat different interpretation: while younger persons seem to read better than the older persons among whites, the same does not appear to be true for blacks. The evidence is perhaps the strongest for white females and the weakest for black females. While both father's education and mother's education appear to have a positive effect on schooling, their effects on reading scores seem to be quite different for whites and blacks.[15] The effects of father's and mother's education on reading are negative and positive respectively for whites, but the reverse is true for blacks. For whites it is the effect of mother's education on reading that is significantly positive, but for blacks it is the effect of father's education that is significantly positive.[16] The effect of schooling on reading is statistically significant for all subsamples, but the magnitude of the effect is almost twice as large for blacks as for whites. Finally, the effects of race and sex on schooling and reading appear to be important judging from the statistical significance of the dummy variables in the regressions based on total sample and from the differences among the regressions based on different subsamples.

V. Economic Benefits of Schooling and Compensatory Reading

Most recent studies of the rate of return to education attempted to estimate an empirical earnings function using a semi-logarithmic form or a simple linear form similar to eq. (1) or (2) respectively. In an early study, Mincer (1958) suggested that the rate of return to education can be estimated by the coefficient of years of schooling in a semi-logarithmic form, and most existing studies seem to show that such an approach can indeed be useful. More recently, however, some of the possible limitations of such an approach have become apparent. For example, the estimated rate of return to schooling may be biased because of missing variables that are likely to be correlated with schooling. Griliches and Mason (1972) have examined this problem by considering the effect of ability and found the bias to be insignificant. However, there are some other problems. As more variables are included in the earnings function, it also becomes apparent that a reasonable estimate of the rate of return to schooling cannot be obtained without explicitly taking into account the interrelationships among the explanatory variables. Welch (1973), in his recent study of black-white differences in returns to schooling, has attempted to deal with this problem by considering a set of auxiliary regressions that explain the interrelationships among the explanatory variables. In addition, occasionally the questions regarding whether the dependent variable should be earnings or wage rate and whether work hours should be an explanatory variable in an earnings function have been raised. These and other questions suggest that a study of earnings can perhaps be more meaningful handled by a more detailed labor market analysis, using a multiple-equation approach. In his recent study of wage rate and work hours, Hall (1973) demonstrated the potential of this approach, though his major concern was not directly related to the earnings function. Several other studies, e.g., Weiss (1970) and Blinder (1973), also recognized the importance of a multiple-equation approach. None of the existing studies, however, have attempted to separate the effects of schooling or other determinants of earnings into the effects due to changes in wage rate and work hours. The purpose of this section is to demonstrate how the framework of our previous labor market and educational achievement models can be combined to explain the sources of earnings difference, and thus how the total economic benefits of schooling and compensatory reading may be assessed.[17]

Although the economic benefits of schooling and reading can be estimated directly from the empirical earnings functions such as eqs. (1) and (2), probably with some adjustments as was done by Welch (1973), such an approach will not be followed because, as was pointed out previously, it does not provide a framework for identifying whether wage rate or work hours may be the main source of difference in earnings. Therefore, instead of simply relying on our empirical earnings function, we shall use the definition of earnings that is the product of wage rate and work hours ($Y = Y_1 Y_2$) combined with the empirical results of our labor market and educational achievement models for subsequent discussion. Formally, our analytical structure consists of the definition of earnings, the wage determination and work hours functions, i.e., eqs. (3) and (4), and the determinants of schooling and reading, i.e., eqs. (5) and (6).

To facilitate discussion, we first consider how the partial benefits of schooling and reading or any other factor affecting either wage rate or work hours may be evaluated, ignoring the interrelationships among the determining factors, such as those examined in the educational achievement model. Later we shall consider how these partial benefits may be combined in order to obtain the full economic benefits of schooling and reading, using the empirical relationships of the educational achievement model. It can be verified that the reduced form of the labor market model represented by eqs. (3) and (4) is

$$Y_1 = \{1/(1 - \alpha\beta)\}\{(\alpha_0 + \alpha\beta_0) + \Sigma_{i=1}^{k} (\alpha_i + \alpha\beta_i) X_i + \Sigma_{i=1}^{k} (\alpha_{i+k} + \alpha\beta_{i+k}) X_i^2\}, \qquad (7)$$

$$Y_2 = \{1/(1 - \alpha\beta)\}\{(\beta_0 + \beta\alpha_0) + \Sigma_{i=1}^{k} (\beta_i + \beta\alpha_i) X_i + \Sigma_{i=1}^{k} (\beta_{i+k} + \beta\alpha_{i+k}) X_i^2\}. \qquad (8)$$

which are obtained simply by eliminating Y_2 from eq. (3) and Y_1 from eq. (4). Thus, from the definition of earnings, $Y = Y_1 Y_2$, the partial benefits of any determinant of earnings can be written as

$$\left(\frac{\partial Y}{\partial X_i}\right) = Y_2 \left(\frac{\partial Y_1}{\partial X_i}\right) + Y_1 \left(\frac{\partial Y_2}{\partial X_i}\right), \quad i = 1,2,\ldots,k \qquad (9)$$

where

$$\left(\frac{\partial Y_1}{\partial X_i}\right) = \alpha_i + \alpha \beta_i + 2 \alpha \beta_{i+k} X_i$$

and

$$\left(\frac{\partial Y_2}{\partial X_i}\right) = \beta_i + \beta \alpha_i + 2 \beta \alpha_{i+k} X_i$$

according to eqs. (7) and (8). In our empirical results presented in Tables 3 and 4, most of the parameters α_{i+k} and β_{i+k} are restricted to be zero, since the only squared-variable is work experience. The partial benefits defined above can be clearly decomposed into two components representing wage-rate effect and work-hours effect respectively. Notice that these partial effects depend on the specific forms of the wage determination and work hours functions. Moreover, they depend on which of the other determinants are held constant.

In the discussion of partial benefits we have treated schooling, reading and work experience in the same way as we have treated other exogenous variables such as father's education and mother's education, which are clearly exogenous and beyond the choice of the individuals whose earnings are being analyzed. To evaluate more fully the economic benefits of schooling and reading, it is necessary for us to take into account some possible interrelationships among the explanatory variables that so far have been treated as exogenous. In general, the full benefit of any determinant of earnings can be defined as

$$\left(\frac{dY}{dX_i}\right) = \sum_{j=1}^{k} \left(\frac{dX_i}{dX_j}\right)\left(\frac{\partial Y}{\partial X_i}\right) \quad , \; i=1, 2, \ldots k \tag{10}$$

where $\left(\frac{\partial Y}{\partial X_i}\right)$ are partial benefits previously defined in eq. (9). Thus full benefits are simply weighted sums of partial benefits, dX_i/dX_j being the weights.

Among the many possible interrelationships among the explanatory variables, the most important ones are the definition of work experience and the interrelationships studied in our educational achievement model represented by eqs. (5) and (6). Assuming these are the only interrelationships among the explanatory variables, specific measures of full benefits of schooling and reading can then be computed. From the definition of work experience as a function of age, i.e., $X_3 = X_{[illegible]} - (X_1 + 5)$, we have $dX_3/dX_1 = -1$. From the empirical functions of the determinants of schooling and reading we know that $dX_1/dX_2 = \lambda$ and $dX_2/dX_1 = \mu$, according to eqs. (5) and (6) respectively. Therefore, the full benefits of schooling and reading competence measured in terms of incremental annual earnings may be defined explicitly as

$$\left(\frac{dY}{dX_1}\right) = \left\{\left(\frac{\partial Y}{\partial X_1}\right) - \left(\frac{\partial Y}{\partial X_3}\right)\right\} + \mu\left(\frac{\partial Y}{\partial X_2}\right) \quad , \tag{11}$$

and

$$\left(\frac{dY}{dX_2}\right) = \lambda\left\{\left(\frac{\partial Y}{\partial X_1}\right) - \left(\frac{\partial Y}{\partial X_3}\right)\right\} + \left(\frac{\partial Y}{\partial X_2}\right) \quad , \tag{12}$$

where in both cases the first term represents the benefits attributable to schooling and the second term to reading. Therefore, the first term in eq. (11) and the second term in eq. (12) may be regarded as direct benefits of schooling and reading competence, and the second term in eq. (11) and the first term in eq. (12) their corresponding indirect benefits. Notice that, in general, these benefits are functions of age, schooling and other background variables, since partial benefits are functions of wage rate and work hours.

Full benefits of schooling and reading competence as defined in eqs. (11) and (12) can be expanded and rearranged as

$$\left(\frac{dY}{dX_1}\right) = Y_2 \left\{ \left(\frac{\partial Y_1}{\partial X_1}\right) - \left(\frac{\partial Y_1}{\partial X_3}\right) + \mu \left(\frac{\partial Y_1}{\partial X_2}\right) \right\} + Y_1 \left\{ \left(\frac{\partial Y_2}{\partial X_1}\right) - \left(\frac{\partial Y_2}{\partial X_3}\right) + \mu \left(\frac{\partial Y_2}{\partial X_1}\right) \right\}, \quad (13)$$

$$\left(\frac{dY}{dX_2}\right) = Y_2 \left\{ \lambda \left[\left(\frac{\partial Y_1}{\partial X_1}\right) - \left(\frac{\partial Y_1}{\partial X_3}\right) \right] + \left(\frac{\partial Y_1}{\partial X_2}\right) \right\} + Y_1 \left\{ \lambda \left[\left(\frac{\partial Y_2}{\partial X_1}\right) - \left(\frac{\partial Y_2}{\partial X_3}\right) \right] + \left(\frac{\partial Y_2}{\partial X_2}\right) \right\}, \quad (14)$$

where the first terms are the effects of wage rate on full benefits of schooling and reading, and the second terms the corresponding effects of work hours. The decompositions of full benefits of schooling and reading into wage-rate and work-hours effects as suggested in eqs. (13) and (14) are not only useful in themselves but also convenient in order to compute some other measures of benefit. For example, similar to Eckaus (1973), alternative measures of benefits may be computed by assuming work-hours are fixed at the same level for all individuals. Thus, adjusted benefits of schooling and reading competence may be computed by dividing the first terms of eqs. (13) and (14) by the ratio of observed work hours to the fixed, say 2,000 hours, and ignoring the second terms representing the effects of work hours. An implicit assumption used in these measures is that individuals always work full time, either in the labor market, as self-employed, or in household production. These measures of adjusted benefits, though they clearly have some limitation, may be useful especially in indicating maximum benefits of schooling or reading.

So far we have discussed benefits of schooling and reading only in terms of incremental annual earnings. We have pointed out these benefits are in general functions of age, schooling and other background variables. By holding all other variables constant, for example, at the observed mean levels and letting only age vary, we can construct a stream of annual earnings increments realizable at any given age due to an incremental change in schooling or reading. The present value of this stream of benefits, discounted at some appropriate discount rate, provides a more complete measure of the economic benefits of schooling or reading. Formally the present values of full benefits of schooling and reading may be computed from

$$\int_n^m \left(\frac{dY}{dX_1}\right) e^{-r(X_7-n)} dX_7 \qquad (15)$$

and

$$\int_n^m \left(\frac{dY}{dX_2}\right) e^{-r(X_7-n)} dX_7 \qquad (16)$$

where n is the current age and m is the retirement age. For practical purposes, the present values of full benefits of schooling and reading may be computed by discrete approximations of eqs. (15) and (16), so that indefinite integration may be avoided.

Finally, it must be pointed out that benefits of schooling and reading previously discussed are all marginal benefits reflecting changes in benefits due to changes in one unit of schooling or reading (evaluated at a given schooling or reading level). The total benefits of schooling or reading, measured in terms of annual earnings, due to changes over several units of schooling or reading can also be computed as

$$\int_n^m \left(\frac{dY}{dX_1}\right) dX_1 \qquad (17)$$

and

$$\int_n^m \left(\frac{dY}{dX_2}\right) dX_2 \qquad (18)$$

where n and m are the initial schooling or reading level and the targeted schooling or reading level respectively. Clearly corresponding average benefits are obtained simply by dividing eqs. (17) and (18) by m-n, representing the range of change in schooling or reading. These measures are particularly useful to answer such questions as: what are the possible economic benefits of increasing the level of schooling from n years to m years or the level of reading competence from n to m standardized score? Given the distribution of the initial schooling or reading competence, the possible benefits of a given educational program that would raise the schooling or reading level of all individuals to a given targeted schooling or reading level can also be computed. For example, we can compute the economic benefit of a compensatory reading program that would raise the reading competence of all individuals whose scores are under a given targeted level up to that targeted level, say the present national mean (zero in standardized scores). Although we have discussed the concept of average and total benefits only in terms of annual earnings, these same concepts can be applied to the present values explained in eqs. (15) and (16). That the numerical value of such a computation should be used with extreme caution goes without saying. One is both extrapolating from marginal to large changes and ignoring the possibility of nonoptimizing producer choice or market signalling effects (Spence, 1974, Chapters 3 and 4). Nonetheless we feel the computations do place a rough upper limit on the total benefits to be expected. The empirical results of the benefits of schooling and reading based on the concepts discussed above are presented in Tables 8 and 9. The results presented here are based on the empirical relationships given in Tables 4 through 7 assuming recursive structures for both labor market and educational achievement models. It should be noted that, since our assumed recursive structure has schooling affecting reading, but not vice versa, there may be some tendency to overstate the relative benefits of schooling and understate those of compensatory reading education.

In Table 8, the estimates of alternative measures of private benefits of schooling are presented. The table is divided into two parts: the first part gives the estimates of alternative measures of marginal benefit for an additional year of schooling at approximately the high school level, and the second part provides the estimates of total benefits for a representative individual and the nation as a whole for two hypothetical compulsory educational programs. The estimates of partial and full benefits of schooling, as defined in eqs. (9) and (11), are computed at the mean levels of all explanatory variables. In general, these two measures are very close to each other, with full benefits somewhat lower than partial benefits largely because of adjustments for benefit due to experience. The estimated full benefits, measured in terms of increases in annual earnings, are the highest for white males ($1,121) and the lowest for white females ($517). The corresponding full benefits for black males and females are $663 and $783 respectively. When the full benefits are decomposed according to eq. (13) into the wage-rate and work-hours effects, it is apparent that most effects are due to wage rate rather than work hours. It is interesting to note that most estimated work-hour effects are negative, except for white females. The estimated adjusted benefits, similar to Eckaus (1973), are computed by dividing the first terms of eq. (13) by the ratio of actual work hours to full-time work hours (2,000 hours). Because the ratios of actual work hours to full-time work hours are close to one, and the work-hour effects are generally small, the results of adjusted benefits are not very different from the corresponding original estimates of full benefits. The present values of full benefit streams are computed at age 18, assuming retirement at age 65. The effect of discount rate on the magnitude of present value is shown by providing results for zero, 5% and 10% discount rates. It is important to note that the present values with 10% discount rate are perhaps very close to the mean earnings on individuals at age 18, suggesting that the private rates of return to schooling are approximately 10%, except for black females whose rate of return to schooling appears to be somewhat higher.

The estimated total benefits of two hypothetical compulsory educational programs must be received with great caution. The estimated benefits are based on the assumption that all individuals (age 25 and over) whose educational levels are lower than the targeted level (either high school or college graduation) were able to complete the compulsory education at the targeted level, and that they were able to obtain the same earnings as presently observed for the targeted levels of schooling. It is also assumed that no benefit (or loss) will occur to individuals whose levels of schooling are already above the targeted level. The total benefits for a representative individual of the hypothetical compulsory educational programs are computed by

$$\int_{o}^{m} \left(\frac{dY}{dX_1}\right) f(X_1 | X_1 < m) dX_1 \qquad (19)$$

where $f(X_1 | X_1 < m)$ is the conditional distribution of individuals by educational level, and m is either 12 or 16, corresponding to high school and college graduation respectively. These total benefits are in effect measures of average benefits of all individuals whose education is under the given targeted level. As the table shows, the estimated benefits of the hypothetical compulsory high school education for a representative individual are the highest for white males ($3,810) and the lowest for white females ($1,370). The corresponding estimated benefits for black males and females are $2,580 and $1,940 respectively. The estimated benefits of the hypothetical compulsory college education for a representative individual can be interpreted analogously. Finally, the national program benefits are computed simply by multiplying the representative individual benefits by the corresponding total numbers of individuals completing less than high school or college education. The actual figures used for the numbers of individuals (age 25 and over) completing less than high school or college education are for 1970 taken from the Statistical Abstract of the United States 1972, No. 168. As the table shows, the estimated national program benefits of the hypothetical compulsory high school education are substantial: approximately $76 billion and $40 billion for white males and females and $8 billion and $7 billion for black males and females respectively. The estimated national program benefits of the hypothetical compulsory college education are even higher. It must be recognized, however, that practically such hypothetical programs cannot be realistically implemented.

We have so far discussed only our estimates of benefits of schooling as shown in Table 8. The corresponding estimates of benefits of reading competence are reported in Table 9, which is also divided into two parts: marginal benefit and total benefit. The estimates of partial and full benefits, as defined in eqs. (9) and (12), are also computed at the mean levels of all explanatory variables. The partial and full benefits, shown under the heading of marginal benefit, are identical because the underlying educational achievement model is recursive, i.e., $\lambda=0$ in eq. (12). As the table shows, the benefits of reading competence for males are larger than for females. In fact, our result shows that the benefits of reading competence is negative for black females. Whether this result can be taken seriously is, however, not clear to us. It is important to note that when full benefits are decomposed according to eq. (14) into wage-rate and work-hours effects, we find that the wage-rate effect is more important for white males but the work-hours effect is more important for black males. In addition, it is interesting to note that the wage-rate and work-hours effects are in opposite direction and almost cancelling the effects of each other completely for white females. The interpretation of the estimated adjusted benefits and present values at various discount rates are analogous to those of Table 8.

In the second part of Table 9, the estimated total benefits of two hypothetical compensatory reading programs, with low and high reading targets, are provided. We must stress that these estimates, like the similar estimates for the two hypothetical compulsory educational programs given in Table 8, must be received with great caution. The total benefits for a representative individual of the hypothetical compensatory reading programs are computed by

$$\int_{-\infty}^{m} \left(\frac{dY}{dX_2}\right) f(X_2 | X_2 < m)\ dX_2 \qquad (20)$$

where $f(X_2 | X_2 < m)$ is the conditional distribution of individuals by standardized reading score, and m is either -1 or zero, corresponding to a low or high target compensatory reading program. As the table shows, the estimated benefits of the low target compensatory reading program for a representative individual are $323 and $273 for white males and black males respectively, and only $12 for white females and negative for black females. The estimated benefits of the high target compensatory reading program for a representative individual are somewhat higher as may be expected, except for black females.

The national program benefits are computed by multiplying the representative individual benefits by the corresponding estimated numbers of individuals whose reading competence, measured by standardized scores, is likely to fall below -1 or zero, using the frequency distributions of 1972 <u>National Reading Survey</u> and population figures (age 25 and over) for 1970 obtained from <u>Statistical Abstract of the United States 1972</u>, No. 168. The total benefits of a national program which raises everyone's reading competence to a level represented by -1 of standardized reading score are estimated to be approximately $2 billion and $71 million respectively for white males and females and approximately $609 million and negative respectively for black males and females. The estimated benefits of the high reading target national program are, as expected, generally higher. Their interpretations are analogous, and therefore need no further explanation. Finally, we wish to emphasize again that these estimated benefits are very tentative. They may be biased downward for one reason, but biased upward for another reason.[18] Furthermore, like the hypothetical compulsory educational programs discussed previously, the goals of the hypothetical compensatory reading programs may be practically infeasible to achieve.

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Footnotes

[1] We are aware of only a few prior studies dealing with the relation between literacy and earning. One is by Carnoy and Lockheed-Katz (1971) using Brazilian data; while they had insufficient information to specify an earnings function, they did find a positive association between literacy and earnings. "Simmons (1972,1974) found little correlation between literacy or self-assessed literacy on the one hand and earnings on the other."

[2] See R. Murphy (1973) for a detailed discussion of how the test instruments were developed and implemented.

[3] One series of studies of correlations between personality variables and income, though restricted to graduates of the Master of Business Administration (MBA) program of the Stanford Graduate School of Business, does provide direct support for the Gintis position. Harrell (1969, 1970) and Harrell and Harrell (1974) found that high earning MBSs tend to have more "ascendant" personalities and were "...overwhelmingly in the socially desirable direction on the personality measures" (Harrell, 1969, p. 461). Harrell and Harrell found a significant negative (simple) correlation between verbal score and earnings of MBAs, and attributed this to differences they found in personality. It would be of interest to ascertain the extent to which this finding would hold up in a multivariate (i.e., earnings function) analysis.

[4] Although experience-squared is included as an explanatory variable in our estimations, eq. (2) is referred to as simple linear for convenience. In our early analyses, we have estimated the earnings function with

cross-product terms attempting to explain the interactions between schooling and reading and between experience and reading. According to the results of semi-log earnings function, most of these interactions are positive. While the experience and reading interaction is more significant for white males, the schooling and reading interaction appears to be more significant for white females as well as for blacks of both sexes.

[5] The term "work experience," throughout the present study, should be understood as potential work experience as previously defined. For males, potential and actual work experience are probably very close; females, however, after marriage, spend less than half their lifetime in the labor market on the average, and our data are unable to provide information on the actual amount. Mincer and Polachek (1974) have used the National Longitudinal Survey data to estimate the effects of actual labor market participation on women's earnings.

[6] This result is in general consistent with the evidence provided by existing studies which indicates that the most important parental influences on the adult earnings of their children are indirect rather than direct. Thus, the effects of parents' education on schooling, and, to a lesser extent, literacy does make a contribution to future earnings, but the effects can be traced only through estimation of the type of recursive system estimated later in this paper. For a review of some of the existing literature, see C.R. Hill and F.P. Stafford (1974).

[7] More rigorous testing procedure along the line suggested by G. Chow (1960) has not been performed. Our maintained hypothesis is that each subsample should be represented by an earnings function of its own.

[8] This is because the rate of return to schooling, according to eq. (1) suggested by Mincer (1958), is $\partial \ln Y/\partial X_1$ which equals $(\partial Y/\partial X_1)/Y$.

[9] Our results are thus consistent with those of Welch (1973) that returns to education are now as high for blacks as whites. This is in contrast to earlier findings, but the more recent data used by Welch and by us suggests that there has been a change over time.

[10] This simply reflects a particular normalization rule. The idea has been indicated by R. Hall (1973). No satisfactory empirical result, however, has been provided.

[11] Although the same notation is used for the error terms of eqs. (1) and (3), and similarly for eqs. (2) and (4), they are in general different.

[12] These problems of identification are standard in the labor supply literature that uses survey data; see, for discussion, the papers in the volume edited by Cain and Watts (1973) or Metcalf, Nickell, and Richardson (1974).

[13] Henry Levin suggested the potential importance of this trade-off to us.

[14] In preliminary analyses we constructed, as an alternative to mother's and father's education, a measure of their education <u>relative</u> to what the education of a person their age would be, using a prediction of their age based on the respondent's age. This transformation affected the results in no substantial or consistent manner, so we returned to the more simple education variable.

[15] Recall that the reading scores were constructed as "standardized scores," since ten different test booklets were administered. More specifically, the reading scores are defined as $(P_{ij} - \bar{P}_j)/S_j$, where P_{ij} is the proportion of right answers for i individual using j booklet and $\bar{P}_j$ and S_j are mean and standard deviation of P_{ij}. These standardized scores were based on all items in each booklet. Our supplementary study on the possible effect of deleting some "inappropriate" items on the results of our analysis indicates that such an effect can be expected to be relatively minor, since the correlations of standardized scores based on all items and "selected" items only are highly correlated. Transformations of reading scores were also experimented with. In particular, a transformation of reading score was defined as $-N_{ij}(1 + k)^{N_{ij}}$ where N_{ij} is the number of wrong answers for the i individual using j booklet divided by the ratio of the mean of the number of wrong answers for j booklet to that of all booklets, and k is a given constant, which was assigned a value ranging from -0.5 to 0.5. The results corresponding to eqs. (5) and (6) generally suggest that there is no significant difference among alternative transformations of reading scores. In addition,

in Appendix B, we also examine the effects of substituting discontinuous variables for schooling and reading scores.

[16] For the results of some other studies on the effect of parent's education on schooling, see C.R. Hill and F.P. Stafford (1974) or Woodhall (1973, p. 288).

[17] The analytical framework developed here may have other potentially significant applications, for example, in analyzing an important issue on the sources of inflation and real economic growth. The analogy between this problem and the one discussed in the text is apparent, since inflation and real output correspond to wage and work hours respectively.

[18] For example, these estimates of total benefits of reading competence may be biased downward because of our imposed assumption of "linear" effect, a possibility examined more fully in our Appendix B. On the other hand, these estimates may be biased upward because of our failure to consider the issue in a general equilibrium framework.

TABLE 1

SAMPLE MEANS AND STANDARD DEVIATIONS OF VARIOUS SUBSAMPLES IN NATIONAL READING SURVEY, 1972

(AGE 25 to 60, WHITE AND BLACK)

	Variable	Total	White		Black	
			Male	Female	Male	Female
Y	Earnings (thousands of dollars per year)	9.5973 (6.2233)	12.5931 (6.0149)	5.7527 (4.1263)	7.6585 (4.1986)	5.2938 (2.7634)
LnY	Earnings (log)	1.9967 (0.8155)	2.3982 (0.5655)	1.4660 (0.8160)	1.8660 (0.6306)	1.4862 (0.6688)
Y_1	Wage Rate (dollars per hour)	5.4595 (4.8225)	6.7177 (5.0562)	3.9292 (4.2174)	4.1087 (2.0859)	3.0780 (1.5818)
Y_2	Work Hours (thousands of hours per year)	1.7953 (0.4614)	1.9297 (0.2674)	1.6003 (0.5978)	1.8481 (0.3729)	1.7577 (0.4699)
X_1	Schooling (years)	12.7943 (2.8502)	12.9966 (3.0154)	12.6636 (2.5217)	11.1081 (3.1610)	12.5001 (2.5892)
X_2	Reading (standardized score)	-0.0001 (1.0003)	0.0627 (0.9655)	0.0580 (0.8922)	-1.1459 (1.4568)	-0.7685 (1.3172)
X_3	Experience (years of potential job experience)	21.5528 (11.1516)	21.0706 (11.0995)	22.2741 (11.1426)	21.6378 (12.0450)	21.0488 (10.6809)
X_3^2	Experience-squared	588.8828 (526.4469)	567.1686 (522.6717)	620.2948 (521.6531)	613.2794 (627.0424)	557.1324 (517.4029)
X_4	Father's Education (years)	9.0333 (4.2195)	8.9992 (4.3023)	9.2169 (4.1228)	7.8690 (3.4863)	8.4834 (4.3956)
X_5	Mother's Education (years)	9.3382 (3.7903)	9.3932 (3.8704)	9.3296 (3.7008)	8.4974 (3.4604)	9.3252 (3.6612)
X_6	Other Income (thousands of dollars per year)	8.1233 (12.0290)	6.2262 (11.4253)	11.3307 (12.5611)	3.2470 (6.7874)	7.0111 (10.7111)
X_7	Age (years)	39.3472 (10.2675)	39.0672 (10.1515)	39.9378 (10.3722)	37.7460 (10.4891)	38.5488 (10.3696)
X_8	Race (black = 0, white = 1)	0.0589 (0.2355)	---	---	---	---
X_9	Sex (female = 0, male = 1)	0.4131 (0.4924)	---	---	---	---
X_{10}	Employment Status (part time=0, full time=1)	0.2998 (0.4582)	0.2168 (0.4121)	0.4315 (0.4953)	0.1744 (0.3795)	0.2709 (0.4444)
	Number of Observations	2308	1287	891	73	57

TABLE 2

REGRESSION RESULTS OF SEMI-LOG EARNINGS FUNCTION[a,b]

Explanatory Variable	Total	White		Black	
		Male	Female	Male	Female
Schooling	0.0822 (20.78)	0.0765 (17.24)	0.0874 (10.48)	0.0743 (3.24)	0.1515 (6.07)
Reading	0.0484 (4.68)	0.0590 (4.67)	0.0339 (1.68)	0.0261 (0.73)	-0.0011 (-0.02)
Experience	0.0293 (8.40)	0.0474 (11.32)	0.0079 (1.22)	0.0178 (1.06)	0.0033 (0.14)
Experience-squared	-0.0005 (-6.20)	-0.0008 (-8.84)	-0.0001 (-0.44)	-0.0003 (-1.05)	-0.0001 (-0.13)
Father's Education	0.0004 (0.13)	0.0005 (0.14)	0.0012 (0.22)	0.0130 (0.67)	0.0143 (0.76)
Mother's Education	0.0031 (0.98)	0.0045 (1.22)	0.0041 (0.67)	-0.0092 (-0.45)	-0.0519 (-2.41)
Work Hours	0.8642 (42.33)	0.7529 (18.78)	0.8973 (33.23)	0.8761 (6.91)	0.7176 (6.15)
Race	-0.1560 (-4.02)	---	---	---	---
Sex	-0.6198 (-32.37)	---	---	---	---
Constant	-0.7384 (-9.48)	-0.6544 (-6.06)	-1.2656 (-9.18)	-0.7556 (-1.90)	-1.3414 (-2.88)
R^2	0.6093	0.3528	0.5055	0.5216	0.5210
F	577.14	143.72	187.18	15.36	12.77

[a]The dependent variable is the log of the number of thousands of dollars of annual earnings.

[b]t-values are expressed in parentheses below parameter estimates.

TABLE 3

REGRESSION RESULTS OF LINEAR EARNINGS FUNCTION [a,b]

Explanatory Variable	Total	White		Black	
		Male	Female	Male	Female
Schooling	0.8087 (23.63)	0.9321 (19.22)	0.5550 (11.39)	0.6889 (4.10)	0.6580 (5.90)
Reading	0.2903 (3.24)	0.4699 (3.39)	0.0311 (0.26)	0.1274 (0.49)	-0.0824 (-0.37)
Experience	0.3651 (12.08)	0.5455 (11.87)	0.0891 (2.35)	0.0960 (0.78)	0.0409 (0.39)
Experience-squared	-0.0058 (-9.19)	-0.0088 (-9.08)	-0.0011 (-1.37)	-0.0010 (-0.45)	-0.0004 (-1.89)
Father's Education	0.0263 (1.07)	0.0193 (0.53)	0.0365 (1.17)	0.1585 (1.12)	0.0811 (0.97)
Mother's Education	-0.0175 (-0.64)	-0.0064 (-0.16)	0.0016 (0.05)	-0.1254 (-0.84)	-0.1671 (-1.74)
Work Hours	3.7545 (21.25)	5.3516 (12.18)	3.3272 (21.09)	3.6071 (3.88)	2.1396 (4.10)
Race	-1.7205 (-5.12)	---	---	---	---
Sex	-5.3440 (-32.24)	---	---	---	---
Constant	-9.7003 (-14.39)	-16.5161 (-13.95)	-8.2620 (-10.25)	-8.1316 (-2.79)	-6.5195 (3.13)
R^2	0.4974	0.3123	0.3400	0.4218	0.4395
F	366.20	119.73	94.35	10.28	9.21

[a]The dependent variable is the number of thousands of dollars of annual earnings.

[b]t-values are expressed in parentheses below parameter estimates.

TABLE 4

REGRESSION RESULTS OF WAGE DETERMINATION FUNCTION [a,b]

Explanatory Variable	Total	White Male	White Female	Black Male	Black Female
Schooling	0.5678 (16.76)	0.6724 (14.81)	0.3306 (5.55)	0.3919 (4.23)	0.4535 (7.16)
Reading	0.1025 (1.16)	0.1813 (1.40)	0.0459 (0.32)	0.0355 (0.25)	-0.0521 (-0.42)
Experience	0.2250 (7.53)	0.3058 (7.16)	0.1198 (2.58)	0.0679 (1.00)	-0.0031 (-0.05)
Experience-squared	-0.0038 (-6.07)	-0.0051 (-5.68)	-0.0020 (-2.08)	-0.0009 (-0.70)	0.0002 (0.14)
Father's Education	-0.0248 (-1.02)	-0.0655 (-1.94)	0.0425 (1.12)	0.0580 (0.76)	0.0353 (0.75)
Mother's Education	-0.0588 (-2.15)	-0.1019 (-2.68)	0.0457 (1.05)	-0.0730 (-0.89)	-0.1520 (-2.79)
Race	-1.0865 (-3.27)	---	---	---	---
Sex	-2.6187 (-16.97)	---	---	---	---
Constant	-2.4999 (-4.21)	-4.0333 (-4.85)	-2.4904 (-2.64)	-0.9569 (-0.67)	-1.5405 (-1.34)
R^2	0.1794	0.1454	0.0529	0.2804	0.4397
F	91.07	52.37	11.95	6.47	10.88

[a]The dependent variable is wages expressed in dollars per hour.

[b]t-values are expressed in parentheses below parameter estimates.

TABLE 5

REGRESSION RESULTS OF WORK HOURS FUNCTION [a,b]

Explanatory Variable	Total	White		Black	
		Male	Female	Male	Female
Schooling	0.0152 (4.39)	0.0063 (2.39)	0.0246 (2.86)	-0.0018 (-0.09)	0.0404 (1.29)
Reading	0.0001 (0.01)	0.0058 (0.84)	-0.0129 (-0.64)	0.0289 (1.01)	-0.0833 (-1.84)
Experience	0.0139 (4.76)	0.0178 (7.64)	0.0051 (0.77)	0.0020 (0.15)	0.0265 (1.21)
Experience-squared	-0.0002 (-3.14)	-0.0003 (-6.42)	0 (0.22)	0.0001 (0.23)	-0.0005 (-1.18)
Father's Education	-0.0008 (-0.33)	0.0018 (0.99)	-0.0071 (-1.33)	0.0306 (1.98)	0.0308 (1.72)
Mother's Education	0.0024 (0.90)	0.0011 (0.52)	0.0029 (0.47)	0.0071 (0.44)	0.0049 (0.22)
Other Income	-0.0011 (-1.62)	0.0014 (2.60)	-0.0034 (-2.55)	0.0065 (1.14)	-0.0006 (-0.10)
Wage	-0.0216 (-12.81)	-0.0178 (-13.96)	-0.0306 (-7.77)	-0.0082 (-0.41)	-0.0653 (-1.57)
Race	0.0044 (0.14)	---	---	---	---
Sex	-0.3704 (-23.15)	---	---	---	---
Constant	1.6779 (28.86)	1.7342 (38.01)	1.3547 (10.10)	1.5319 (5.25)	0.8218 (1.87)
R^2	0.1648	0.1172	0.0645	0.1498	0.162
F	65.68	30.60	11.05	2.15	1.72

[a]The dependent variable is the number of thousands of hours the respondent worked in 1972.

[b]t-values are expressed in parentheses below parameter estimates.

TABLE 6

REGRESSION RESULTS OF DETERMINANTS OF SCHOOLING [a,b]

Explanatory Variable	Total	White Male	White Female	Black Male	Black Female
Father's Education	0.1776 (13.29)	0.1903 (10.04)	0.1724 (9.21)	0.1769 (1.87)	0.0573 (0.72)
Mother's Education	0.1856 (12.28)	0.1488 (6.94)	0.2168 (10.19)	0.3811 (3.93)	0.2715 (3.00)
Age	-0.0149 (-3.38)	-0.0186 (-2.86)	-0.0078 (-1.32)	-0.0868 (-3.89)	0.0309 (1.18)
Race	-0.8637 (-4.71)	---	---	---	---
Sex	-0.2570 (-2.94)	---	---	---	---
Constant	10.1987 (42.38)	10.6111 (30.50)	9.3639 (28.35)	9.7532 (8.69)	8.2909 (5.98)
R^2	0.2402	0.1947	0.3090	0.4640	0.1883
F	210.80	149.09	191.65	29.62	6.66

[a]The dependent variable is the number of years of schooling attained by the respondent.

[b]t-values are expressed in parentheses below parameter estimates.

TABLE 7

REGRESSION RESULTS OF DETERMINANTS OF READING [a,b]

Explanatory Variable	Total	White Male	White Female	Black Male	Black Female
Father's Education	0.0001 (0.02)	-0.0037 (-0.60)	-0.0122 (-1.65)	0.1134 (2.20)	0.1612 (4.35)
Mother's Education	0.0322 (6.03)	0.0430 (6.36)	0.0270 (3.21)	-0.0527 (-0.95)	-0.1367 (-3.10)
Schooling	0.1331 (22.24)	0.1274 (17.60)	0.1382 (12.99)	0.2142 (4.06)	0.2070 (4.14)
Age	-0.0029 (-1.92)	-0.0026 (-1.27)	-0.0051 (-2.24)	0.0227 (1.78)	0.0004 (0.03)
Race	-0.8759 (-13.79)	---	---	---	---
Sex	0.0517 (1.71)	---	---	---	---
Constant	-1.8590 (-18.02)	-1.8639 (-14.04)	-1.6296 (-10.15)	-4.8244 (-6.10)	-3.4641 (-4.53)
R^2	0.2637	0.2389	0.1979	0.2859	0.3330
F	199.02	145.12	79.28	10.17	10.63

[a] The dependent variable is the respondent's standardized reading score on a literacy test,

[b] t-values are expressed in parentheses below the parameter estimates.

TABLE 8

ALTERNATIVE MEASURES OF BENEFIT OF SCHOOLING

		White		Black	
	Total	Male	Female	Male	Female
I. Marginal Benefit[a]					
Partial Benefit	$ 1,042	$ 1,278	$ 581	$ 706	$ 863
Full Benefit	931	1,121	517	663	783
Wage Effect	939	1,186	482	687	805
Hour Effect	-8	-65	35	-23	-22
Adjusted Benefit	1,046	1,229	602	743	916
Present value of Full Benefit					
No discount	46,236	56,306	25,520	33,188	36,116
5% discount	15,594	18,518	8,871	12,331	13,586
10% discount	7,972	9,270	4,655	6,809	7,447
II. Total Benefit					
Compulsory High School Education					
Representative Individual[b]	$ 2,900	$ 3,810	$1,370	$2,580	$1,940
National Program (Billions)[c]	142.3 (120.9)	76.0	29.9	8.1	6.9
Compulsory College Education					
Representative Individual[b]	4,040	4,910	2,200	3,430	3,380
National Program[c] (Billions)	428.5 (332.8)	194.1	103.7	15.1	19.9

[a] These are marginal private benefits of one additional year of school.

[b] The total benefits given for a representative individual are computed by

$$\int_0^m (dY/dX_i)\ f(X_i | X_i < m)\ dX_i$$

where $f(X_i / X_i < m)$ is the conditional distribution of individuals by educational level, and m is either 12 or 16, corresponding to high school and college graduation respectively.

[c] The national program benefits are computed by multiplying the representative individual benefits by the corresponding total numbers of individuals (age 25 and over) completing less than high school or college education for 1970 taken from Statistical Abstract of the United States 1972, No. 168, p. 112. Figures in parentheses for total samples are derived by summing the benefits for all four subsamples.

TABLE 9

ALTERNATIVE MEASURES OF BENEFITS OF READING COMPETENCE

	Total	White Male	White Female	Black Male	Black Female
I. Marginal Benefit					
Partial Benefit	$ 172	$ 375	$ 12	$ 187	$ -341
Full Benefit	172	375	12	187	-341
Wage Effect	185	356	72	66	-95
Hour Effect	-13	19	-60	121	-246
Adjusted Benefit					
Present value of Full Benefit	$ 206	$ 369	$ 90	$ 71	$ -108
No discount	8,267	17,606	303	8,956	-16,357
5% discount	3,224	6,830	384	3,385	-6,359
10% discount	1,832	3,848	249	1,876	-3,604
II. Total Benefit					
Low Reading Target (Standardized reading score = -1)					
Representative Individual[a]	$ 161	$ 323	$ 12	$ 273	$ -392
National Program (Millions)[b]	2,552 (1,809)	2,002	71	609	-873
High Reading Target (Standardized reading score = 0)					
Representative Individual[a]	163	332	12	340	-490
National Program (Millions)[b]	7,216 (5,476)	6,004	237	1,098	-1,863

[a] The total benefits given for a representative individual are computed by $\int_{-\infty}^{m} (dY/dX_2)\, f(X_2 | X_2 < m)\, dX_2$ where $f(X_2/X_2 < m)$ is the conditional distribution of individuals by standardized reading score, and m is either -1 or zero, corresponding to a low or high target compensatory reading program.

[b] The national program benefits are computed by multiplying the representative individual benefits by the corresponding estimated numbers of individuals whose reading competence, measured by standardized scores, are below -1 or zero, using the frequency distributions of 1972 National Reading Survey and population figures (ages 25 and over) for 1970 obtained from Statistical Abstract of the United States 1972, No. 168, p. 112. Figures in parentheses for total sample are derived by summing the benefits for all four subsamples.

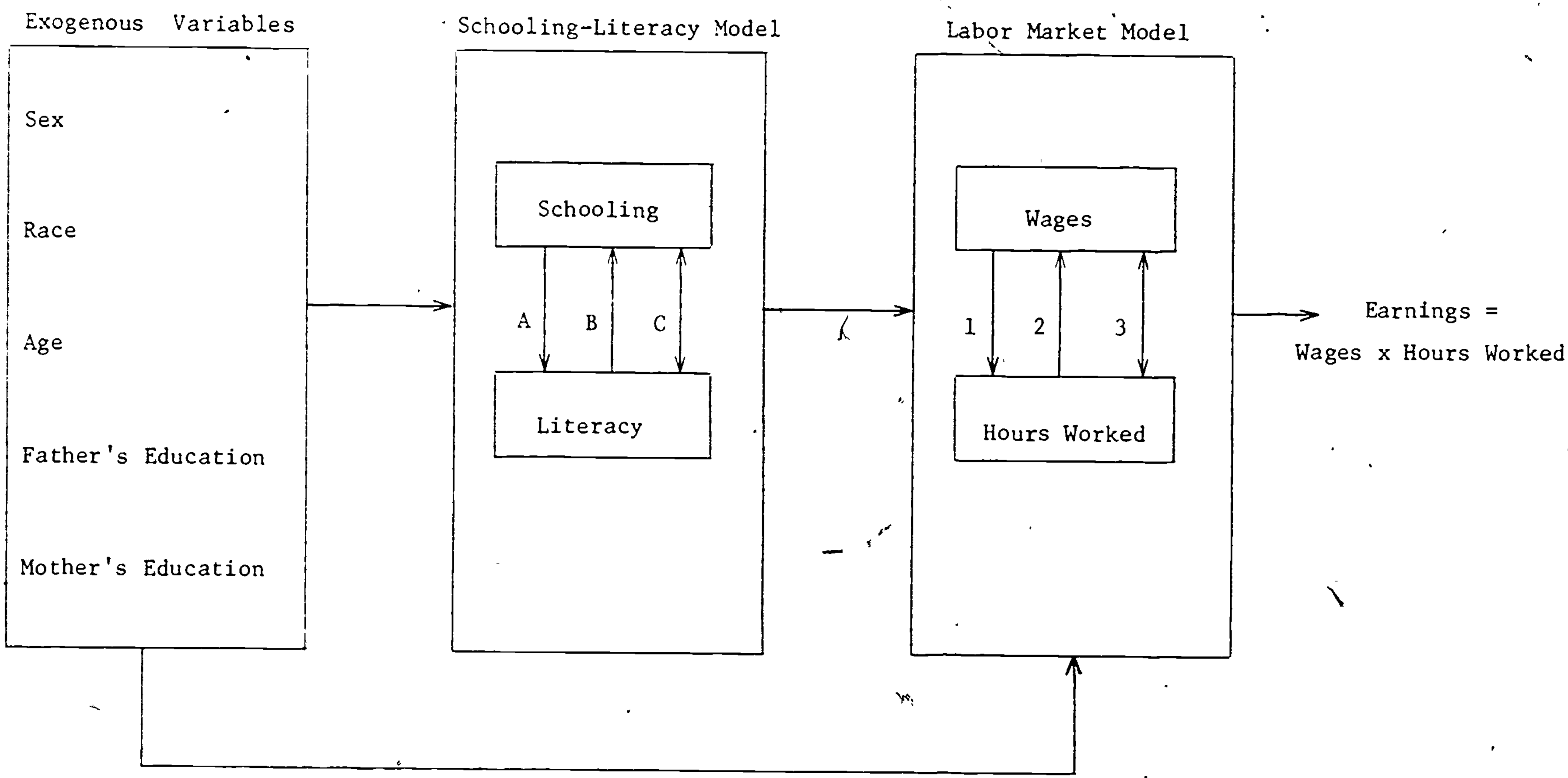

Figure 1

Block Recursive Models of Determinants and Effects of Schooling and Literacy

APPENDIX A: CORRELATION MATRICES

Tables A-1 through A-5 contain the correlation matrices of the variables used in the study. Table A-1 is the correlation matrix for the total sample; Tables A-2 to A-4 are the matrices for the four subsamples.

APPENDIX TABLE A-1

CORRELATION MATRIX: TOTAL SAMPLE

	Y Earnings	Ln Y Log of Earnings	Y_1 Wage Rate	Y_2 Work Hours	X_1 Schooling	X_2 Reading	X_3 Experience	X_3^2 Experience Squared	X_4 Father's Education	X_5 Mother's Education	X_6 Other Income	X_7 Age	X_8 Race
Y Log of Earnings	0.898												
Wage Rate	0.620	0.508											
Work Hours	0.430	0.620	-0.092										
Schooling	0.340	0.287	0.281	-0.007									
Reading	0.195	0.175	0.147	-0.016	0.456								
Experience	0.003	-0.013	-0.019	0.063	-0.426	-0.234							
Experience-squared	-0.023	-0.029	-0.040	0.057	-0.411	-0.246	0.973						
Father's Education	0.105	0.091	0.051	-0.023	0.437	0.263	-0.322	-0.295					
Mother's Education	0.108	0.113	0.047	-0.004	0.434	0.302	-0.377	-0.361	0.643				
Other Income	0.119	0.013	0.135	-0.111	0.189	0.100	0.045	0.025	0.106	0.065			
Age	0.098	0.066	0.057	0.067	-0.185	-0.128	0.968	0.943	-0.228	-0.290	0.101		
Race	-0.122	-0.094	-0.095	0.006	-0.092	-0.243	-0.004	-0.001	-0.052	-0.031	-0.066	-0.030	
Sex	-0.522	-0.545	-0.276	-0.336	-0.042	0.004	0.048	0.044	0.027	-0.002	0.204	0.041	0.023

APPENDIX TABLE A-2

CORRELATION MATRIX: WHITE MALE

	Y Earnings	Ln Y Log of Earnings	Y_1 Wage Rate	Y_2 Work Hours	X_1 Schooling	X_2 Reading	X_3 Experience	X_3^2 Experience Squared	X_4 Father's Education	X_5 Mother's Education	X_6 Other Income
Ln Y Log of Earnings	0.928										
Y_1 Wage Rate	0.613	0.545									
Y_2 Work Hours	0.256	0.373	-0.274								
X_1 Schooling	0.380	0.349	0.297	-0.051							
X_2 Reading	0.241	0.254	0.151	-0.004	0.462						
X_3 Experience	0.062	0.048	0.021	0.091	-0.437	-0.258					
X_3^2 Experience-squared	0.010	-0.004	-0.013	0.066	-0.428	-0.273	0.972				
X_4 Father's Education	0.125	0.133	0.006	0.018	0.407	0.261	-0.321	0.292			
X_5 Mother's Education	0.107	0.136	-0.012	0.017	0.382	0.322	-0.370	-0.353	0.635		
X_6 Other Income	0.358	0.256	0.266	0.007	0.209	0.070	0.071	0.059	0.098	0.062	
X_7 Age	-.180	0.156	0.111	0.085	-0.181	-0.145	0.965	0.936	-2.230	-0.291	0.140

APPENDIX TABLE A-3

CORRELATION MATRIX: WHITE FEMALE

	Y Earnings	Ln Y Log of Earnings	Y_1 Wage Rate	Y_2 Work Hours	X_1 Schooling	X_2 Reading	X_3 Experience	X_3^2 Experience Squared	X_4 Father's Education	X_5 Mother's Education	X_6 Other Income
Ln Y Log of Earnings	0.892										
Y_1 Wage Rate	0.476	0.336									
Y_2 Work Hours	0.480	0.654	-0.212								
X_1 Schooling	0.303	0.252	0.209	-0.026							
X_2 Reading	0.119	0.118	0.102	-0.040	0.432						
X_3 Experience	0.003	0.008	-0.040	0.102	-0.408	-0.243					
X_3^2 Experience-squared	0.005	0.015	-0.048	0.106	-0.381	-0.249	0.974				
X_4 Father's Education	0.137	0.092	0.139	-0.068	0.487	0.225	-0.332	-0.303			
X_5 Mother's Education	0.132	0.110	0.140	-0.051	0.512	0.293	-0.399	-0.378	0.652		
X_6 Other Income	0.108	0.040	0.092	-0.081	0.173	0.105	-0.007	-0.038	0.108	0.082	
X_7 Age	0.077	0.070	0.008	0.103	-0.195	-0.156	0.975	0.954	0.082	-0.304	0.034

APPENDIX TABLE A-4

CORRELATION MATRIX: BLACK MALE

	Y Earnings	Ln Y Log of Earnings	Y_1 Wage Rate	Y_2 Work Hours	X_1 Schooling	X_2 Reading	X_3 Experience	X_3^2 Experience Squared	X_4 Father's Education	X_5 Mother's Education	X_6 Other Income
Ln Y log of Earnings	0.914										
Y_1 Wage Rate	0.907	0.807									
Y_2 Work Hours	0.429	0.597	0.084								
X_1 Schooling	0.513	0.464	0.506	0.131							
X_2 Reading	0.361	0.360	0.291	0.210	0.466						
X_3 Experience	-0.151	-0.157	-0.205	0.094	-0.592	-0.127					
X_3^2 Experience-squared	-0.163	-0.181	-0.215	0.078	-0.579	-0.145	0.974				
X_4 Father's Education	0.427	0.427	0.312	0.317	0.513	0.409	-0.189	-0.227			
X_5 Mother's Education	0.365	0.379	0.289	0.237	0.611	0.323	-0.323	-0.357	0.719		
X_6 Other Income	0.294	0.236	0.262	0.097	0.217	0.012	0.029	0.010	-0.052	0.061	
X_7 Age	-0.018	-0.041	-0.083	0.148	-0.378	-0.006	0.970	0.944	-0.062	-0.187	0.099

APPENDIX TABLE A-5

CORRELATION MATRIX: BLACK FEMALE

	Y Earnings	Ln Y Log of Earnings	Y Wage Rate	Y Work Hours	X Schooling	X Reading	X Experience	X Experience Squared	X Father's Education	X Mother's Education	X Other Income
Ln·Y Log of Earnings	0.929										
Y_1 Wage Rate	0.821	0.724									
Y_2 Work Hours	0.368	0.483	-0.156								
X_1 Schooling	0.547	0.524	0.602	0.063							
X_2 Reading	0.186	0.193	0.244	-0.084	0.408						
X_3 Experience	-0.075	-0.131	-0.070	-0.088	-0.240	-0.214					
X_3^2 Experience-squared	-0.060	-0.117	-0.032	-0.113	-0.203	-0.212	0.975				
X_4 Father's Education	0.203	0.203	0.060	0.244	0.296	0.410	-0.445	-0.424			
X_5 Mother's Education	0.195	0.167	0.005	0.289	0.417	0.137	-0.314	-0.335	0.646		
X_6 Other Income	0.427	0.339	0.511	-0.085	0.436	0.277	-0.034	-0.005	0.106	-0.124	

APPENDIX B

TESTS FOR LINEARITY OF EFFECTS BY USING DISCRETE VARIABLES

The purpose of this appendix is to report some supplementary regression results of empirical earnings functions using dummy variables to represent different levels of schooling and reading competence. In Section II, schooling and reading competence are represented by years of schooling and standardized scores in computing empirical earnings function, implicitly assuming that the effects of these two variables (measured by the associated coefficients) are the same at different levels of schooling and reading competence. This appendix summarizes the empirical results of an attempt to verify the reasonability of this implicit assumption. Specifically, the schooling and reading scores variables in eqs. (1) and (2) are substituted by the following set of six dummy variables, four of them representing schooling and the other two representing reading competence:

School Dummy 1: 5 to 8 years of schooling = 1, otherwise = 0
School Dummy 2: 9 to 12 years of schooling = 1, otherwise = 0
School Dummy 3: 13 to 16 years of schooling = 1, otherwise = 0
School Dummy 4: 16 and more years of schooling = 1, otherwise = 0
Reading Dummy L: Standardized scores below minus one = 1, otherwise = 0
Reading Dummy H: Standardized scores above one = 1, otherwise = 0.

The results of the empirical earnings function using these dummy variables for schooling and reading competence are reported in Appendix Tables B-1 and B-2, using logarithmic values of earnings and earnings respectively as the dependent variables. These results are comparable with those reported in Tables 2 and 3 in the text. In general, the results shown here are similar to the corresponding results shown in

Tables 2 and 3 of the text. It is important to note that while the assumption of constant schooling effect in eqs. (1) and (2) appears to be acceptable, the similar assumption for reading competence seems to be more questionable. This conclusion is derived from the observation that the estimated coefficients of the four school dummies seem to increase at a roughly constant rate as schooling level increases, and that the magnitudes of the estimated coefficients of the two reading dummies (in terms of absolute values) are considerably different from each other. The results of Appendix Tables B-1 and B-2 generally show that individuals with low reading scores can be expected to have lower earnings, with a possible exception of black females. Whether individuals with high reading scores can be expected to have higher earnings, however, is not very conclusive from our results, perhaps because the reading test instruments were designed only to reveal functional reading ability. This result suggests that the economic benefit of reading obtained by assuming a constant effect for all levels of reading competence may tend to underestimate the true effect. Finally, it may be pointed out that while the school dummies are usually statistically significant, especially for school dummies 3 and 4, school dummies 1 and 2 for white females turn out to have negative estimated coefficients.

APPENDIX TABLE B-1

SUPPLEMENTARY SEMI-LOG EARNINGS FUNCTION[a,b]

Explanatory Variable	Total	White		Black	
		Male	Female	Male	Female
School Dummy 1	0.3402 (2.80)	0.7414 (4.26)	-0.3494 (-1.33)	0.2603 (0.96)	0.1762 (0.31)
School Dummy 2	0.5585 (4.63)	0.9500 (5.46)	-0.1277 (-0.49)	0.4654 (1.76)	1.0214 (1.90)
School Dummy 3	0.8271 (6.75)	1.2156 (6.93)	0.1007 (0.38)	0.7528 (2.46)	1.5708 (2.88)
School Dummy 4	1.0789 (8.64)	1.4070 (7.93)	0.4815 (1.80)	0.9581 (2.50)	2.0418 (3.36)
Reading Dummy L	-0.1634 (-5.62)	-0.1667 (-4.58)	-0.1709 (-3.12)	-0.1403 (-1.28)	0.0820 (0.58)
Reading Dummy H	0.0360 (1.37)	0.0432 (1.44)	0.0250 (0.51)	0.0075 (0.03)	-0.0420 (-0.19)
Experience	0.0295 (8.04)	0.0462 (10.49)	0.0117 (1.73)	0.0117 (0.66)	-0.0080 (-0.33)
Experience-squared	-0.0005 (-6.1413)	-0.0008 (-8.30)	-0.0002 (-1.11)	-0.0002 (-0.68)	0.0002 (0.32)
Work Hours	0.8715 (42.02)	0.7637 (18.65)	0.9051 (33.31)	0.8574 (6.13)	0.6969 (5.45)
Father's Education	0.0021 (0.73)	0.0028 (0.83)	0.0025 (0.47)	0.0209 (1.02)	0.0144 (0.73)
Mother's Education	0.0216 (1.44)	0.0046 (1.23)	0.0078 (1.28)	-0.0051 -0.25	-0.0511 (-2.35)
Race	-0.1536 (-3.91)	---	---	---	---
Sex	-0.6131 (-31.34)	---	---	---	---
R^2	0.5990	0.3281	0.5043	0.5199	0.5181
F	382.31	81.78	118.19	9.32	7.64

[a]The dependent variable is the log of the number of thousands of dollars of annual earnings.

[b]t-values are expressed in parentheses below parameter estimates.

APPENDIX TABLE B-2

SUPPLEMENTARY LINEAR EARNINGS FUNCTION [a,b]

Explanatory Variable	Total	White		Black	
		Male	Female	Male	Female
School Dummy 1	0.6504 (0.62)	2.7627 (1.44)	-2.0170 (-1.32)	0.7079 (0.37)	0.2265 (0.09)
School Dummy 2	2.6749 (2.55)	4.9729 (2.60)	-0.5910 -0.39)	2.0993 (1.12)	2.9907 (1.28)
School Dummy 3	5.3913 (5.07)	8.4228 (4.37)	0.7696 (0.50)	6.6739 (3.07)	5.9279 (2.50)
School Dummy 4	7.9786 (7.36)	10.9533 (5.62)	3.4436 (2.21)	6.0697 (2.22)	7.73 (2.92)
Reading Dummy L	-1.1352 (-4.50)	-1.4766 (-3.69)	-0.7607 (-2.39)	-0.6632 (-0.85)	0.9217 (1.49)
Reading Dummy H	0.1523 (0.67)	0.3677 (1.12)	-0.2148 (-0.75)	-1.7118 (-0.95)	0.2454 (0.26)
Experience	0.3850 (12.10)	0.5641 (11.65)	0.1156 (2.93)	0.1086 (0.86)	-0.0146 (-0.14)
Experience-squared	-0.0065 (-9.62)	-0.0095 (-9.24)	-0.0017 (-2.07)	-0.0017 (-0.71)	0.0006 (0.26)
Work Hours	3.8571 (21.42)	5.4476 (12.10)	3.3853 (21.40)	3.7299 (3.75)	2.0408 (3.67)
Father's Education	0.0421 (1.70)	0.0429 (1.16)	0.0437 (1.401)	0.2102 (1.44)	0.0867 (1.01)
Mother's Education	0.0002 (0.01)	-0.0006 (-0.02)	0.0250 (0.70)	-0.0605 (-0.42)	-0.1521 (-1.60)
Race	-1.7440 (-5.12)	---	---	---	---
Sex	-5.2478 (-30.91)	---	---	---	---
R^2	0.4812	0.2825	0.3427	0.4529	0.4660
F	237.35	65.94	60.56	7.12	6.20

[a]The dependent variable is the number of thousands of dollars of annual earnings.

[b]t-values are expressed in parentheses below parameter estimates.

APPENDIX C

SIMULTANEOUS LABOR MARKET MODEL

The purpose of this appendix is to supplement the analysis of Section III by considering a simultaneous model of labor market relationships. The simultaneous model in this appendix is different from the recursive model reported in the text mainly in allowing work hours to affect wage rate in wage determination function represented by eq. (3), i.e., $\gamma \neq 0$. In addition, for identification purpose, a new variable referred to as employment status is introduced into eq. (3) as an additional explanatory variable. Thus eq. (3) may be regarded as the inverse demand function for labor, and eq. (4) the supply function of labor. Because both wage rate and work hours are endogenous in the simultaneous model, some simultaneous equation approach must be considered for estimating the parameters in eqs. (3) and (4). In this appendix, the results of the Two-Stage Least Squares (TSLS) procedure are presented in Appendix Tables C-1 and C-2 for the wage determination and work-hours functions respectively. The results of the Ordinary Least Squares (OLS) procedure for the wage determination function, not reported here, are in general very similar to those of the TSLS procedure presented in Appendix Table C-1. The results of the OLS procedure for the work-hours function are identical with those shown in Table 5 in the text.

The results reported in Appendix Table C-1 are obtained by restricting the coefficients associated with employment status to the corresponding estimates obtained in the first stage. These additional restrictions were introduced because the predicted work hours were so highly correlated with employment status (full-time salaried workers or not) that the usual second stage computation in the TSLS procedure became infeasible due to singularity of a matrix to be inverted. In Appendix Table C-2, the coefficient of schooling for black males was restricted to be zero, since the corresponding estimate in the first stage is negative, contrary to the usual expectation, and without such a restriction the computation was not feasible also due to singularity. Aside from these restrictions which were imposed only to avoid computational difficulties, the empirical results of Appendix Tables C-1 and C-2 are obtained following the usual TSLS procedure. One of the reasons the recursive model was selected for discussion in the text is based on the fact that, while work hours seem to be a significant factor determining wage rate for the whites, the same does not appear to be true for the blacks. In addition, as was just mentioned, the introduction of an employment status variable for identification purpose resulted in computational difficulties. We thus present these simultaneous estimations only tentatively.

The empirical results of Appendix Table C-1 are similar to those of Table 4, which did not include employment status and predicted work hours as additional explanatory variables. The empirical results of Appendix Table C-2, however, are considerably different from those of Table 5 in the text. Recall that, besides a minor restriction introduced on the parameter associated with schooling variable for black males, the only difference between Appendix Table C-2 and Table 5 is the use of observed wage rate or predicted wage rate as an explanatory variable. As Appendix Table C-2 shows, the use of predicted wage rate has in general increased the goodness-of-fit considerably, except for black males. In fact, all coefficients in the work-hours functions for white males, white females and black females are highly statistically significant, except work experience for black females. In general, the effects of schooling, reading and work experience all appear to be much stronger than those of the OLS estimates employed for the recursive model as shown in Table 5. In particular, the effects of reading and work hours are highly significantly positive for white males and white females, but negative for black females. The estimated effects of father's education and mother's education on work hours are very different from those of the OLS estimates.

APPENDIX TABLE C-1

REGRESSION RESULTS OF WAGE DETERMINATION FUNCTION [a] (TSLS)

Explanatory Variable	Total	White Male	White Female	Black Male	Black Female
Schooling	0.5758 (17.08)	0.6545 (14.45)	0.3770 (6.34)	0.3696 (3.97)	0.4559 (7.24)
Reading	0.0995 (1.13)	0.1909 (1.48)	0.0353 (0.25)	0.0519 (0.36)	-0.0872 (-0.70)
Experience	0.2461 (8.25)	0.3648 (8.34)	0.1272 (2.75)	0.0671 (0.98)	0.0153 (0.26)
Experience-squared	-0.0041 (-6.53)	-0.0061 (-6.71)	-0.0019 (-1.97)	-0.0009 (-0.71)	-0.0002 (-0.16)
Father's Education	-0.0248 (-1.03)	-0.0500 (-1.48	0.0235 (0.62)	0.0641 (0.81)	0.0506 (1.06)
Mother's Education	-0.0505 (-1.85)	-0.0883 (-2.33)	0.0425 (0.98)	-0.0704 (-0.85)	-0.1439 (-2.65)
Employment Status	-0.6399 (b)	-0.2392 (b)	-1.5554 (b)	-0.7422 (b)	0.1926 (b)
Work Hours	-2.5813 (-9.76)	-4.6021 (-5.70)	-2.4739 (-9.91)	-0.7307 (-1.25)	-0.3364 (-0.95)
Race	-1.0635 (-3.21)	---	---	---	---
Sex	-3.3083 (-18.88)	---	---	---	---
Constant	2.1277 (2.84)	4.2151 (2.54)	1.5366 (1.52)	0.7638 (0.46)	-1.4445 (-1.21)
R^2	0.1953	0.1597	0.1225	0.2630	0.4461
F	89.83	50.11	25.56	5.03	9.45

[a] t-values are placed in parentheses below the parameter estimates.

[b] These estimates were restricted to the given value to avoid multicollinearity.

APPENDIX TABLE C-2

REGRESSION RESULTS OF WORK-HOURS FUNCTION [a] (TSLS)

Explanatory Variable	Total	White Male	White Female	Black Male	Black Female
Schooling	0.3680 (47.91)	0.1475 (23.01)	0.4290 (38.59)	(b)	0.7554 (13.43)
Reading	0.0718 (10.60)	0.0573 (8.55)	0.0375 (2.81)	0.0298 (0.99)	-0.1750 (-6.68)
Experience	0.1493 (41.83)	0.0839 (23.99)	0.1421 (26.19)	0.0022 (0.17)	0.0011 (0.09)
Experience-squared	-0.0025 (-37.49)	-0.0015 (-22.28)	-0.0022 (-21.06)	0.0001 (0.23)	0.0002 (0.67)
Father's Education	0.0237 (-12.70)	-0.0171 (-9.33)	0.0433 (11.66)	0.0314 (1.84)	0.0443 (4.41)
Mother's Education	-0.0355 (-16.29)	-0.0240 (-11.26)	0.0628 (14.73)	0.0067 (0.44)	-0.1788 (-9.59)
Other Income	0.0336 (38.76)	0.0217 (21.98)	0.0155 (15.84)	0.0069 (0.96)	0.0642 (11.05)
Wage (predicted)	-0.7055 (-50.30)	-0.2611 (-25.29)	-1.3070 (-43.02)	-0.0156 (0.26)	-2.0021 (-13.65)
Race	-0.6599 (-23.31)	---	---	---	---
Sex	-2.3348 (-55.63)	---	---	---	---
Constant	0.4732 (9.24)	1.0731 (21.52)	-1.6306 (-14.46)	1.5378 (5.49)	-0.8942 (-3.23)
R^2	0.5020	0.2751	0.5994	0.1484	0.7381
F	335.65	87.54	239.55	2.46	28.60

[a] t-values are placed in parentheses below the parameter estimates.

[b] This parameter was restricted to be zero.

APPENDIX D

SIMULTANEOUS MODEL OF EDUCATIONAL ACHIEVEMENTS

In Section IV of the text, the empirical results of a recursive model of educational achievements have been examined. The purpose of this Appendix is to supplement those results by examining the empirical results of a simultaneous model in which not only schooling is assumed to affect reading but also reading is assumed to affect schooling. In order to identify eqs. (5) and (6), in eq. (5) we replaced father's education and mother's education by a single variable constructed by summing the years of schooling of both parents, i.e., restricting the parameters associated with father's education and mother's education to be the same. In addition, in eq. (6), we assumed that father's education does not affect reading for total sample and subsamples of white males and white females but that mother's education does. For black males and females, however, we assumed father's education, rather than mother's education, affects reading. These restrictions, imposed for identification purposes, are largely based on empirical results and are admittedly somewhat arbitrary.

The empirical results of the Two Stage Least Squares (TSLS) estimation of the simultaneous model of educational achievements are presented in Appendix Tables D-1 and D-2 for the determinants of schooling and reading respectively. The corresponding results of the Ordinary Least Squares (OLS) estimation are not reported here. The most striking differences between these two sets of estimated values using TSLS and OLS respectively are the coefficients associated with reading in eq. (5) and those associated with schooling in eq. (6), representing the interaction between these two variables. While these coefficients are highly significant when the observed reading scores and schooling level were used in eqs. (5) and (6), as in the OLS procedure, the same is not generally true when the predicted reading scores and schooling level were used instead, as in the TSLS procedure (Appendix Tables D-1 and D-2).

Among the determinants of schooling examined in Appendix Table D-1, father's and mother's education clearly has a significantly positive effect for all subsamples. The effect of age is generally negative, reflecting a general trend of increasing educational level, with a possible exception of black females. The effect of reading on schooling is generally not significant and mostly turns out to be negative, possibly because of the oversimplified structure of our simultaneous model. Among the determinants of reading scores considered in Appendix Table D-2, mother's education is statistically significant for whites and father's education is for blacks. The effect of age on reading is negative for whites and positive for blacks, but statistically significant only for white females. The effect of schooling on reading is generally positive, except for black females. However, only the estimated coefficients for the total sample and the subsample of white males are statistically significant. In general, our results do indicate that the recursive model considered in the text ($\lambda=0$, $\mu\neq0$) is more plausible than the other type of recursive model ($\lambda\neq0$, $\mu=0$). Finally, the effects of race and sex are obvious either from the results of dummy variables or from comparisons among corresponding regressions obtained for various subsamples.

APPENDIX TABLE D-1

REGRESSION RESULTS OF DETERMINANTS OF SCHOOLING[a] (TSLS)

Explanatory Variable	Total	White Male	White Female	Black Male	Black Female
Father's Education[b]	0.1719 (5.59)	0.2109 (5.87)	0.1610 (5.91)	0.4294 (3.14)	0.2035 (4.07)
Mother's Education[b]	0.1719 (5.59)	0.2109 (5.87)	0.1610 (5.91)	0.4294 (3.14)	0.2035 (4.07)
Reading (predicted)	0.2412 (0.31)	-1.0032 (-1.14)	0.9781 (1.23)	-1.6703 (-1.45)	-0.8449 (-1.40)
Age	-0.0137 (-2.27)	-0.0235 (-2.91)	-0.0018 (-0.23)	-0.0799 (-3.33)	0.0366 (1.42)
Race	-0.6247 (-0.80)	---	---	---	---
Sex	-0.2613 (-2.96)	---	---	---	---
Constant	10.3198 (24.33)	10.0978 (19.26)	9.6922 (24.75)	5.1837 (1.19)	6.8140 (3.94)
R^2	0.2402	0.1947	0.3090	0.4640	0.1883
F	210.80	149.09	191.65	29.62	6.66

[a] t-values are placed in parentheses below the parameter estimates.

[b] These estimates were constrained to have the same magnitude for father's education as for mother's education.

APPENDIX TABLE D-2

REGRESSION RESULTS OF DETERMINANTS OF READING [a] (TSLS)

Explanatory Variable	White			Black	
	Total	Male	Female	Male	Female
Father's Education [b]	---	---	---	0.1378 (1.83)	0.1900 (4.05)
Mother's Education [c]	0.0321 (3.32)	0.0456 (4.17)	0.0424 (2.58)	---	---
Schooling (predicted)	0.1335 (4.79)	0.1082 (3.23)	0.0675 (1.53)	0.0758 (0.52)	-0.2963 (-1.76)
Age	-0.0029 (-1.70)	-0.0029 (-1.27)	-0.0056 (-2.30)	0.0107 (0.54)	0.0159 (1.10)
Race	-0.8755 (11.99)	---	---	---	---
Sex	0.0518 (1.57)	---	---	---	---
Constant	-1.8635 (-5.96)	-1.6597 (-4.21)	-0.9674 (-2.12)	-3.4751 (-1.95)	0.7087 (0.41)
R	0.1545	0.1114	0.0925	0.1702	0.1986
F	121.87	77.26	43.71	7.02	7.12

[a] t-values are placed in parentheses below the parameter estimates.

[b] Father's education was constrained to have a zero coefficient for the total sample and the white subsamples.

[c] Mother's education was constrained to have a zero coefficient for the black subsamples.