

BLACK-WHITE DIFFERENCES IN SCHOOLING INVESTMENT AND
HUMAN CAPITAL PRODUCTION IN SEGREGATED SCHOOLS

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No. 133

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The lower level of school quality available for blacks relative to whites in the segregated era is frequently cited as a primary cause for the currently observed gap in black-white average wages. The inferior education provided to black children is argued to have caused lower levels of human capital production in black schools than white schools. The gap in black-white wages can be traced to this gap in human capital. Similarly, the convergence in black and white average wages during the 1960's and 1970's may be explained by the steady convergence in black and white school quality and attendance which began in the 1940's.¹

Given the presumed importance of school quality differences in explaining both the existence of and the changes in black-white wage differentials, our knowledge of the human capital production process in the segregated schools is quite weak. While studies of educational production processes exist, virtually all cover periods following the 1954 Supreme Court ruling against "separate-but-equal" schools. We therefore have no direct evidence regarding the extent to which differences in black-white school characteristics may explain the differences in human capital investment and production between black and white children in the segregated era.

The objective of this paper is to present an econometric analysis of the determinants of achievement and attendance in black and white segregated schools, utilizing data from Maryland grade schools from 1924 through 1938.

The results show that differences in black-white school characteristics explain nearly all of the differences in attendance and achievement between black and white children in the period. In addition, the observed differences in human capital between black and white children are similar in magnitude to the observed differences in wages of blacks and whites schooled in the period. Finally, the school characteristics which proved important in explaining achievement in this sample exhibited tendencies to converge across races later in the century, signalling a convergence in human capital production between blacks and whites. These findings provide extremely strong support for the role of school quality in explaining the differences in human capital investment and production and the resulting differences in wages between blacks and whites.

The discussion will proceed as follows: Section I briefly reviews the applicability of existing studies of educational production functions to the study of school achievement in the segregated period. The next two sections present an alternative modelling strategy to analyze attendance and human capital production. Section IV introduces the data as applied to the theoretical model. The estimation is reported in Section V.

I. The Application of Current Studies of Educational Production to Educational Production in the Past

If the educational production process were stable over time, we should be able to use studies of school quality and human capital production in more recent periods to make inferences about school achievement in the 1930's and 1940's. If these studies consistently demonstrated the importance of a few school characteristics, we could infer the time path of black

and white human capital production from the time paths of these characteristics in the segregated era. However, these studies often disagree as to which characteristics explain school achievement,² and two influential studies (Coleman (1966) and Jencks (1972)) have questioned whether school quality has a major role in determining achievement at all.

Even if these studies agreed on the importance of some set of school characteristics on achievement, there is reason to be cautious in applying these results from more recent periods to human capital production in earlier periods. The reason is that the convergence in school quality measures across school districts over time may have contributed to the common finding that these characteristics do not matter or that these characteristics are less important than socio-economic factors. For example, we would certainly expect that school attendance would be a productive input in the human capital production process. If a student devotes more time to learning, he should learn more. However, if all students allocate the same amount of time to learning, school attendance will explain none of the variation in measured achievement among them. It would be wrong to conclude from this that attendance does not affect student achievement. The small or insignificant parameter for attendance does not imply that attendance is unimportant in determining the level of achievement; only that attendance is unimportant in explaining the differences in achievement across districts.

Ironically, the school characteristics typically used to illustrate the convergence of school quality across races are nearly uniformly found to be unimportant in educational production studies. As an example, the characteristics Welch (1973) uses to illustrate the convergence of school

quality across racial groups, namely school attendance, teacher salaries, length of school term and expenditures per pupil, have little or no effect in most studies of achievement in the 1960's and 1970's. Many studies do not even include these variables in their production relationships at all.

An even more compelling difficulty in using the educational production studies to analyze the effects of school quality on black and white human capital production lies in the lack of a theoretical basis underlying the specification of the estimated production process. The method involves an ad hoc specification of a relationship between school achievement and school characteristics without mapping out the decision-making process involved. Although the schooling process involves decisions on how much to invest in human capital production, this decision-making process is not formally confronted. Yet, if these investment decisions are based upon an individual's perceptions of the productivity of the school, attendance decisions contain information on the productivity of school characteristics. Thus, relative attendance paths may contain information necessary to test the relative effectiveness of black and white schools in producing marketable human capital.³ One method for utilizing this information is presented in the next two sections.

II. The Demand for Schooling

We assume that parents make the decisions regarding the proportion of time their child will spend in school.⁴ This decision is based on a utility maximization framework in which parents derive satisfaction from their child's achievement in school. Parents are assumed to know the learning process by which school characteristics and child time spent in school are translated into human capital by imbedding this educational production

process into the parents' maximization problem, we can derive a demand function for schooling which reveals sign predictions between the attendance and educational production equations.

Let the parents' utility function be characterized as

$$U = U(Q,G) \tag{1}$$

where Q is the amount of human capital the children acquire in the schooling period and G is a Hicksian aggregate commodity. U is assumed to be a concave function in its arguments so that $U'_i > 0$, and $U''_{ij} < 0$ for $i=j$. The parents maximize their utility subject to the full budget constraint

$$w^D + w^C = Aw^C + G \tag{2}$$

where w^D is the parents' wage, w^C is the child's wage, and A is the proportion of available time the child spends in school. Child time, parent time and the price of the composite good are all normalized at one. Parents are assumed to work fulltime so that parent leisure is exogenous to the model. Child time is restricted to either time in school or time in wage work, so child leisure is also exogenous.⁵ Thus, child work time is equal to $(1-A)$.

The production process for Q is assumed to depend upon prior accumulations of human capital K_0 , a vector of home inputs into the production process H , and a vector of school inputs S . H represents inputs such as the socio-economic status of the family, parental educational attainment, and the influence of the child's peers or siblings.⁶ The child has access to these inputs regardless of whether or not he attends school. However, school inputs are available to the child only if he attends school. This implies that the child's proportion of time spent in school is the proportion of the school characteristics actually used in human capital production.

Letting K be the stock of child human capital at the end of the schooling period, we can express the production of human capital within the period as

$$K - K_0 = Q = \beta AS + \delta H + \gamma K_0$$

where β , δ and γ are production parameters.⁷

S may contain elements of H and K_0 if these inputs have different marginal productivity while the child is in school. School characteristics may be productive or unproductive, so that β may be positive, negative or zero.

We assume that H and K_0 are fixed prior to the schooling period and that the school characteristics are exogenous to the parents. Thus, the parents' problem involves choosing A and G so as to maximize their utility.

Imposing the production function (3) on the utility function (1) and maximizing with respect to A , G , and λ , we derive the first order conditions

$$\begin{aligned} U_1 \beta S - \lambda w^c &\leq 0 \\ U_2 - \lambda &\leq 0 \\ w^p + (1-A)w^c - G &\geq 0 \end{aligned} \tag{4}$$

where λ is the marginal utility of income. If the choices of A and G are interior solutions, the equalities in (4) hold, so we can derive the attendance decision as

$$A = f(w^p, w^c, S) \tag{5}$$

The full derivatives of the first order conditions may be written

$$\begin{bmatrix} U_{11} \beta^2 S^2 & U_{12} \beta S & -w^c \\ U_{12} \beta S & U_{22} & -1 \\ -w^c & -1 & 0 \end{bmatrix} \begin{bmatrix} dA \\ dG \\ d\lambda \end{bmatrix} = \begin{bmatrix} \lambda - (U_{11} \beta^2 + U_1 \beta) & 0 \\ 0 & 0 & 0 \\ -(1-A) & 0 & -1 \end{bmatrix} \begin{bmatrix} dw^c \\ dS \\ dw^p \end{bmatrix} \tag{6}$$

No unambiguous sign predictions may be derived from the theory. However, if education is a normal good,

$$dA/dw^P = \frac{U_{12}\beta S - U_{22}w^C}{\Delta} > 0$$

where Δ is the determinate of the matrix of second partials, which must be positive. If attendance rises with parental income, it must decline with the child wage since

$$dA/dw^C = \frac{-\lambda}{\Delta} - (1-A)dA/dw^P < 0$$

The effect of school characteristics on attendance is ambiguous, although some information may be gleaned about their signs as well. The effect of S on A is

$$dA/dS = \frac{(U_{11}\beta^2 SA + U_1\beta)}{\Delta}$$

The first term in the numerator is negative, but the second term cannot be signed. The sign and magnitude of dA/dS depends upon the shape of the utility function, the sign of β , and the levels of input and attendance. In particular, if the amount of the input provided by the school is reduced, the attendance is reduced, or the concavity of the utility function is reduced (i.e., U_1 increases in absolute value relative to U_{11}), then the gradient becomes more positive. Furthermore, if the marginal product of a school input declines with attendance, the derivative of attendance with respect to that characteristic must be negative. If the derivative is positive, the marginal product of the input must increase in attendance. In notational form, these predictions are summarized as⁸

$$\beta_i < 0 \text{ implies } dA/dS_i < 0 \text{ for input } i$$

$$dA/dS_i > 0 \text{ implies } \beta_i > 0 \text{ for input } i \quad (7)$$

III. Production Function Estimation

Through their decision on their children's attendance, parents determine how much achievement their children will attain, given the characteristics of the school, the home inputs and the initial endowment of human capital. The endogeneity of the attendance choice has relevance for the estimation of educational production functions such as (3). In particular, if the probability of observing Q is correlated with any of the inputs in (3), the estimated production coefficients will not accurately portray the output of the school. Instead, the effect of school inputs in producing achievement will be measured for only a subset of the school population.

To illustrate this point, rewrite (3) in regression form where u is an additive error term.

$$Q = \beta SA + \delta H + \gamma K_0 + u \quad (8)$$

where Q is measured as a score on an achievement test. When (8) is estimated over the subset of the school population taking the exam, we estimate the conditional expectation

$$E(Q|SSR) = \hat{\beta}SA + \hat{\delta}H + \hat{\gamma}K_0 + E(u|SSR) \quad (9)$$

where SSR is the sample selection rule which determines which children take the exam and $\hat{\beta}$, $\hat{\delta}$, and $\hat{\gamma}$ are estimates of β , δ and γ respectively. If all students are tested, or if the occurrence of an observed test is independent of the regressors, $\hat{\beta}$, $\hat{\delta}$, and $\hat{\gamma}$ will be unbiased estimates.⁹ If, however, the probability of taking the test is correlated with the regressors, the conditional expectation of the errors is nonzero. As Heckman (1979) has observed, this case corresponds to a missing variable problem in which the errors and the regressors are correlated. Thus, the estimated production

parameters will be inconsistent with the true population production parameters.

As an illustration of how the selection problem may lead to perverse results, suppose that there are two kinds of schools, "good" schools and "bad" schools. Good schools have high levels of school characteristics and bad schools have low levels of school characteristics. Also, suppose that schools have no effect on student achievement, but that students are more likely to attend a good school than a bad school. Suppose further that more talented students attend with greater frequency than less talented students. Finally, assume all school districts have equal distributions of natural abilities, and natural ability is solely responsible for a student's achievement.

Figure 1 shows the effects of the nonrandom selection on observed mean achievement in a "poor" school and a "good" school. In both, relatively good students are more likely to attend on the day of the test than relatively bad students, but poor students are more likely to attend in the good school. In neither case does the sample mean correspond to mean achievement in the population. More importantly, observed mean achievement in the good school will be lower than observed mean achievement in the bad school. Using the selected sample of the test scores, school quality would be incorrectly deduced to decrease mean achievement.¹⁰

Correcting for the selection bias requires identifying the selection rule which governs attendance on the day of the test. The natural candidate for this selection rule is the schooling demand function, (5). This selection rule is particularly appealing because it is derived from economic theory, rather than as an ad hoc specification.

To establish the selection rule from the demand for schooling, we take a linear approximation to Equation (5).

$$A = Z\xi + v \quad (10)$$

where Z is a vector of child wages, adult income and school characteristics, and v is an unobserved input uncorrelated with Z which serves as the error in the model. Here, A is a dichotomous variable such that

$$A = 1 \quad \text{iff } v > -Z\xi \quad (11)$$

$$A = 0 \quad \text{iff } v \leq -Z\xi$$

so that Q is observed when A is one and unobserved when A is zero. Equation (9) may then be written

$$E(Q|v > Z\xi) = \beta SA + \delta H + \gamma K_0 + E(u|v > -Z\xi) \quad (12)$$

Following Olsen (1979), we may derive the regression equation¹¹

$$Q = \beta SA + \delta H + \gamma K_0 - \rho\sigma_u \sqrt{3}(1-Z\xi) + \varepsilon \quad (13)$$

where ε is uncorrelated with v . Inclusion of $1-Z\xi$ as a regressor purges the error term of its correlation with the school characteristics, and thus allows consistent estimation of the production parameters.

Because this study uses county averages of student achievement and student attendance, we now extend the analysis of individual choice to the choice of a representative individual in the county. For the demand equation (10), assume that the error terms are independent across days in the school year and across children.¹² We can then sum over the length of term and the population of children so that for T days in school, N children, and M school inputs, the aggregate days of attendance over the year in the county are

$$\sum_{i=1}^N \sum_{k=1}^T A_{ik} = \sum_{j=1}^M \sum_{i=1}^N \sum_{k=1}^T \xi_j Z_{jik} + \sum_{i=1}^N \sum_{k=1}^T v_{ik}$$

The probability of attending on any given day is equal to the average

daily attendance over the school year. We can thus write

$$\bar{A} = \sum_{j=1}^M \xi_j \bar{Z}_j + 1/2 + \bar{v} ; \bar{v} \sim U(0,1/12TN) \quad (14)$$

where the \bar{X} signifies the average over N children and T school days.¹³

Equation (15) states that average daily attendance for a county is a function of average Z 's in the county, where the \bar{Z} vector includes average school characteristics, average child wages and adult income in the county.

For the educational production function (13), let Q be empirically observed as a dichotomous variable which equals 1 if the child meets or exceeds the norm on a nationally standardized achievement test and 0 otherwise. Once again, assume the errors are independent across the population of children. For n children taking the test, the probability of meeting or exceeding the national norm is

$$\bar{Q} = \sum_{j=1}^M \beta_j \bar{S}_j \bar{A} + \delta \bar{H} + \gamma \bar{K}_0 + \rho \sigma_u \sqrt{3}(1 - \bar{Z}\xi) + \bar{\varepsilon}_t \quad (15)$$

where \bar{X} signifies the average over n children taking the exam. $\bar{\varepsilon}$ distributed normally with mean zero and variance σ_ε^2/n . Equation (15) says that the observed probability of attaining the national norm in the sample taking the exam is a function of average school characteristics, home inputs, previous achievements, and the estimated probability of not taking the exam.

Equations (14) and (15) provide the specifications explaining attendance and achievement for a representative student. These equations may be estimated using Generalized Least Squares.¹⁴

IV. Data and Empirical Strategies

The theoretical model is applied to Maryland data consisting of county averages of school attendance and achievement over the period 1924 through 1938. The data were culled from the Annual Reports of the Maryland State Board of Education.¹⁵ The Maryland data are uniquely suited to this study because the State Board of Education kept detailed and consistent statistics on school characteristics for both the 22 black and 23 white county school systems throughout the segregated era.¹⁶ The Baltimore city school system was not under the State system, and is excluded from the sample. The period 1924-1938 is used because reading test scores for both the black and white schools were available for certain years in that period.¹⁷

The empirical analysis is restricted to the primary school data. The main reason is that grade schools represented most if not all of the schooling that children obtained.¹⁸ A second reason is that, because grade schools concentrate more on a core curriculum, a single measure of school output may reasonably characterize the human capital produced in the school. At the secondary level, the curricula become more diverse, and thus it becomes more difficult to adequately portray the school's learning output with one measure of achievement. A final reason to concentrate on the primary level is that the parents are more likely to be the agents making the choice. At the secondary level, decisions on schooling may be divided between children and parents. This would make the theoretical model based on parental choice less applicable.

Definitions and summary statistics for the variable are presented in Table 1. The dependent variable in the demand equation, ADA, is the ratio of average daily attendance to the number of children enrolled in the county

grade school system. Given our independence assumption for the v 's, ADA represents the probability of attending on any given day including the day of the test.

The dependent variable in the production function is measured as the proportion of students taking a nationally standardized test of reading skills who meet or exceed the national norm for the test. Although the tests differ from year to year, referencing over a common standard of national achievement makes comparison of tested ability feasible. The tests were generally given over the grades 2 through 7, so achievement represents the average achievement in the grade schools as a whole. Tests were given in the white schools in years 1924, 1928, 1932 and 1935. They were administered in the black schools in years 1924, 1932, 1935 and 1938. In total, there are 92 observations for the white schools and 82 for the black schools.¹⁹

The school characteristics include measures of class size, school property value, length of term, teacher education and experience and school consolidation. Class size is measured as the ratio of enrolling or attending pupils to teachers. In the demand function, PTRAT is the proportion of students enrolled per teacher. For the production function, PTRAT is the proportion of students in average attendance per teacher. The difference arises from the use of a different sample of students in the demand equation than in the production equation. The full sample of enrolled pupils is used in the demand equation, but only the selected sample of pupils attending on the test date is used in the production equation.²⁰ Similarly, VALUE is the assessed valuation of school property and equipment per enrolled student for the attendance equation and per average attendance for the achievement equation. TERM is the length of the school term, CERT is the proportion of

teachers with at least a normal school education²¹, EXPI is the proportion of teachers with at least one year of experience, and SMLSCH is the proportion of schools with only one or two teachers. The last four variables are measured identically in the two equations.

Child and adult wages are measured by the proxy variable, WAGE. WAGE captures variations in the value of labor on the farm due to yearly fluctuations in agricultural prices or agricultural productivity.²² In years when agricultural prices are high or crop yields are large, the child wage (the child's value as a laborer in the home) rises as does the opportunity cost of schooling. Because parents are assumed to work fulltime, home labor adjustments are made by altering the allocation of child time between the school and the home.²³ If education is a normal good, the coefficient on WAGE should be negative.

ASSET is a measure of the average value of land and buildings per farm per county per year. These figures were reported separately for nonwhites and whites in Maryland in the U.S. Census of Agriculture every five years. For the intervening years, assets were interpolated. ASSET would have a pure income effect on attendance, so its sign should be positive if education is a normal good.

The other variables control for cost variation in schooling across counties and time. A county specific fixed effect was included to capture county-specific, time-invariant costs of schooling. These are attributed to differences in local transportation costs, labor markets, crop mix, and community literacy rates. An additional variable, DUM31, is a dummy variable controlling for potential differences in schooling demand preceeding a change in the truancy laws in 1931. Its coefficient should be negative

because the earlier, less stringent laws would correspond to higher opportunity costs of child time in school.

WAGE, ASSET, and DUM31 serve to identify the selection process in the production equation. The identification results from the inclusion of these variables in the attendance equation but not in the production equation.²⁴ Unlike previous studies using selection corrections, the exclusion restrictions used here are not imposed in an ad hoc manner, but are derived explicitly from the theory. WAGE, DUM31 and ASSET enter the attendance equation because they represent opportunity costs of schooling or nonwage income in the parents' budget constraint. They do not enter the production equation because they are not inputs into the learning process of the children.

For the production function, the vectors of home inputs common to more recent studies are not available for this study. This lack of data may not be a serious problem here. Commonly used measures of home input into child achievement do not vary markedly over time. Thus, measures such as parents' education or occupation are assumed to be fixed over time and captured by county specific dummy variables. Because of the degree of racial segregation in communities, jobs, churches and schools during this period, a dummy variable conditioning on the racial designation of the segregated school system should more adequately control for differences in social or peer influences than the same variable would for current school systems. CB is this conditional variable; equal to 1 if the school system is black and zero otherwise.

Past achievement is also unavailable because tests were not given in concurrent years.²⁵ However our measure of achievement, the proportion of the population exceeding the national norm for that grade at the conclusion

of the year, helps to mitigate the potential missing variables problem. Standards for passing from one grade to the next divide the population into categories of accumulated human capital, namely those who have attained the level necessary to enter the second grade, the third grade, and so on. Students who already exceed the national norm for their grade at the beginning of the school term should be relatively few in number, since students could be and were given accelerated promotions if their skills were sufficiently advanced. This is admittedly a weak control for lagged achievement, so the problem of omitted variables bias may be only partially corrected by the measure of achievement used.

Treating the home inputs and past accumulations of human capital as fixed effects, (16) may be rewritten as

$$\bar{Q}_i = \sum_{j=1}^M \beta_j \overline{S_{ji} A_i} + \rho \sigma_u \sqrt{3} (1 - \bar{Z}_i \xi) + D_i + \bar{\varepsilon}_i$$

(16)

where D_i is equal to $\delta \bar{H}_i + \gamma \bar{K}_{0i}$ for county i .

V. Results

This section reports the results obtained from the estimation of the attendance and educational production equations. The estimated differences in black and white human capital production are then compared to the observed differences in wages for blacks and whites schooled in the 1930's. Finally, the timing of the convergence in black and white school characteristics is discussed.

A. School attendance

The demand equations were estimated using a generalized least squares

procedure.²⁶ The results appear in Table 2. Tests of equality of the fixed effects across counties were rejected at the .01 level of confidence in both the black and white systems, so only the regressions including county dummy variables are presented. Because the county-specific effects differed significantly between the black and white demand equations, the regressions are reported separately for blacks and whites. The model seems to fit the data quite well for both groups, with 85 percent of the variation in average daily attendance explained by the regressors.

In both systems, ASSET has a positive sign and WAGE and DUM31 have negative signs as expected. The change in truancy laws in 1931 has a greater effect on black attendance, reflecting perhaps relatively lax enforcement of truancy laws in earlier years. ASSET has a significant effect on attendance in the white schools while WAGE has an insignificant effect at standard confidence levels. The opposite pattern is observed in the black schools with WAGE being the more important factor. The result is that black attendance is more sensitive to fluctuations in current local agricultural markets than white attendance. The compensated price elasticity is $-.053$ for black children and $-.011$ for white children, evaluated at their respective sample means. In contrast, the income elasticity is $.036$ for white attendance compared to $.002$ in the black schools.

The school characteristics also perform much as one would expect. Teacher quality in the form of teacher education and experience has a significant positive effect on attendance in both school systems. Schools organized with one or two teachers have significantly lower attendance for both racial groups. The other characteristics switch signs across the demand equations, although these coefficients generally fail significance

tests. PTRAT significantly lowers attendance in the black schools but increases attendance in white schools, albeit by an imprecise amount. Length of term has a positive sign in black schools and a negative sign in the white schools. School value lowers attendance in the black schools and raises attendance in white schools. Neither of the last two variables has a coefficient which exceeds its standard error in either school system.

The theory predicts that if a school characteristic has a positive parameter in the demand equation, the marginal productivity of the characteristic must increase as attendance increases. Therefore, we would predict that CERT, EXPI, PTRAT, and VALUE would have positive coefficients in the white production function and CERT, EXPI and TERM would have positive coefficients in the black production function. The other production parameters may not be signed based upon the demand equation alone.

To see how much of an effect school characteristics have on the attendance choices of black and white children, we can impose white mean school characteristics on the black attendance equation. This empirical equalization of schools results in an increase in mean daily black attendance from 76 percent of enrollment to 80.7 percent of enrollment. This compares to daily attendance in white schools over the period of 82.6 percent of enrollment. When the equalization of school characteristics is performed after the imposition of the 1931 truancy law, expected attendance for black children rises to 83.1 percent compared to 83.0 percent in the white schools. In other words, equalization of school quality between the white and black schools appears to eliminate the differences in school investment decisions of blacks and whites, even when home inputs and family incomes are unchanged.

B. School achievement

Tables 3-4 show the results of the production function estimation. The hypothesis that the fixed effects representing differences in home inputs and past accumulation of human capital were equal across counties could not be rejected at the .05 level of confidence for either the pooled black and white sample or the separate black and white regressions.²⁷ Therefore, results are presented with race specific constants but not county specific effects.

The production parameters estimated over the pooled sample of black and white test results are presented in Table 3. The regression was run both including and excluding the selection correction to illustrate the effects of the endogeneity of attendance choice on the parameter estimates. $1-Z\xi$ is the selection correction, where the ξ are obtained from the attendance equations for the black and white children. Because the parameters of the attendance equations are significantly different across racial groups, the race specific estimates of ξ were used to compute $1-Z\xi$.

The coefficient on $1-Z\xi$ is significantly different from zero, indicating that selection does occur in the allocation of students to the test. The coefficient on the interaction of CB and $1-Z\xi$ indicates that the effect of selection is significantly smaller in the black schools than in the population as a whole. Because $1-Z\xi$ is the predicted probability of not attending school, the positive sign indicates that decreasing the probability of attendance increases the observed proportion of students who meet the national norm on the exam. Thus, observed average mean achievement in the school overstates the true mean achievement in the school due to the nonrandom selection of test takers. Furthermore, schools with the lowest

attendance select out proportionally more low achievement students than high attendance schools. Therefore, observed mean test scores will overstate the true mean by a greater percentage in the low attendance schools, indicating the selection bias is toward understating the impact of school quality on human capital production.

A comparison of the parameter estimates across the two regressions in Table 3 illustrates the effects of selection. The parameters change substantially in a downward direction as expected, although the precision of the estimates is only marginally reduced. The effect is to understate the impact of schools on human capital production and to overstate the impact of home inputs and unobserved school characteristics as captured by the constant. Further evidence of the importance of the selection correction lies in the size of the coefficient on $1-Z\xi$. At sample means, selection accounts for nearly one-third of the observed passing rate on the achievement tests. While 39.1 percent of the students taking the exam met or exceeded the norm, the predicted passing rate over the entire school population is only 26.4 percent. It is apparent that the selection bias is important in this problem and the approach warrants consideration in analogous analyses of selected measures of achievement.²⁸

Looking at the measured effects of school characteristics, we find that the level of teacher certification, teacher experience, length of school term and the value of school property and equipment all have positive and significant effects. The proportion of one and two teacher schools has a significant negative effect. The pupil-teacher ratio has no effect.

These results show school quality to be extremely important compared to production estimates obtained using data from recent periods.²⁹ For instance, most studies have shown that a teacher's educational attainment

or the value of school equipment have little effect on student achievement. However, the estimated negligible impact of these inputs on student achievement in recent years may well be a product of the standardization of these inputs across school systems. Certainly the measured effect of teachers with college training on student achievement will be negligible since all teachers have college training.

TERM and EXP1 have effects similar to those found in studies of more recent school achievement. The positive effects of teacher experience support similar findings by Hanushek (1972), Murnane (1975), and Murnane and Phillips (1980), for more recent data. The positive effect of time spent in school supports similar findings by Kenney (1980) that show school and home study time increase achievement.

Separate regressions were run for the black and white schools to check for satisfaction of the theoretical sign predictions and to test for differences in the production parameters across the segregated systems. Despite the small sample size, the results hold up quite well, although the coefficients are estimated less precisely than in the pooled estimation. Table 4 contains the results for these regressions.

Recall that the equations in (7) require that if a school characteristic has a positive effect on attendance it must have a positive production coefficient. If it has a negative production coefficient, it must have a negative effect on attendance. In the white schools, the positive signs on CERT, EXP, VALUE and PTRAT in the attendance equation successfully predict their positive signs in the production equation.³⁰ The negative signs on TERM and SMLSCH in the production equation successfully predict the negative signs obtained for these school characteristics in the demand equation.

The black production estimates are less precise, perhaps due to greater error in the achievement measure in the black school system.²⁵ Still, the theoretical relationships between the demand and production equations continue to hold. The positive signs on CERT, EXP, and TERM in the production equation were predicted in the black attendance equation, and the negative signs on PTRAT and SMLSCH in the production equation predict the negative effects of these characteristics on black attendance. Coupled with the success of the predictions in the white demand and production equations, these results offer extremely strong support for the theory outlined in Section II.

Correcting for selection, the measure of actual achievement in the white schools is 31.1 percent compared to 15.0 percent in the black schools. Equalizing school quality at the level in the white schools raises the proportion of black students attaining or exceeding the norm by 106 percent, to 30.7 percent of the student population. Of the 15.7 point increase in achievement, 11.4 is due to the improvement in school characteristics alone, holding attendance at its sample mean. The remaining 4.3 is due to the increase in attendance caused by the improvement in the schools. Although this is still slightly lower than the level in the white schools, equalizing school quality appears to substantially narrow the gap in achievement as well as in attendance.

To test the equality of production technology in the black and white schools, we need only test the equality of coefficients across the racial systems. The test statistic $F(6,158)$ is 1.372. This clearly fails to exceed the critical value of the test at the .05 significance level. Therefore, we cannot reject the hypothesis that the school production

coefficients are equal across the black and white school systems. This result supports the contention that equalizing school quality would equalize achievement across the racial systems.

C. Black-White Differences in Human Capital and Wages

Although it is somewhat speculative to proceed from a discussion of school achievement to a discussion of market wages, it is of some interest to note whether the differences in human capital found here might generate the degree of earning inequality between black and white adults educated in this period. Welch (1973) reports returns to education for cohorts entering the labor market between 1934 and 1946 to be .099 for whites and .059 for blacks. Although these returns are averaged over the entire U.S. population rather than just those educated in Maryland, and although they represent the returns to all grades rather than just elementary school, they give a rough estimate of the market value of a year of schooling for blacks relative to whites of about .6.

Table 5 contains the predicted proportion of the black and white grade school aged population which meet or exceed the national norm. The predictions were generated using the results in Table 3. The predictions cover the periods 1924-1930 and 1931-1938, with the latter period corresponding roughly to a population entering the labor force after 1934. The ratio of the predicted human capital produced is much smaller than the ratio of returns to education, and certainly small enough to generate the magnitude of inequality in returns to schooling reported by Welch.

The size of the disparity in the measure of achievement might be considered disturbingly large in comparison to the smaller disparity in earnings. One reason may be that the measure of achievement used in this

study is not an absolute measure but a threshold measure. Let X_b be a random variable representing an absolute measure of achievement for black children and Let X_w be a random variable representing an absolute measure of achievement for white children. Suppose the mean absolute achievement in the white schools corresponds to μ_w and the mean absolute achievement in the black schools is μ_b . Assume the distributions of X_w and X_b are normal with variances σ_w^2 and σ_b^2 , respectively. Also, let μ_N represent the norm score on the exam. Within the black and white school aged populations, we know that $(X_i - \mu_i)/\sigma_i$, $i = b, w$, has the standard normal distribution. From the knowledge of the threshold achievement levels, we know that over the period 1931-1938,

$$\Pr((X_b - \mu_b)/\sigma_b < (\mu_N - \mu_b)/\sigma_b) = .8236$$

$$\Pr((X_w - \mu_w)/\sigma_w < (\mu_N - \mu_w)/\sigma_w) = .6042$$

Using Tables of the standard normal distribution, we obtain the relation

$$\mu_b = -(.93)*\sigma_b + \mu_N$$

$$\mu_w = -(.26)*\sigma_w + \mu_N$$

Table 6 contains the predicted ratio of absolute test scores given various values for the standard deviations in the black and white test scores and assuming a norm score of 50. For a range of "reasonable"³² assumptions for the standard deviations, the ratio μ_b/μ_w ranges from .65 to .8. Thus, even correcting for the possible overstatement of the gap in human capital production, the remaining differences are large enough to account for a substantial portion of the difference in black and white earnings for the period.

D. The Timing of the Convergence in Black and White School Characteristics

The production function estimates indicated that teacher certification, teacher experience, length of term, proportion of one and two teacher schools and value of school property and equipment were all important in the human capital production process in the segregated era. By 1938, teacher experience and certification levels had already become equal in Maryland. Length of term was equalized in Maryland grade schools by 1943. Although black schools gained relative to white schools in value of property per pupil and the number of one and two teacher schools, these inputs were still unequal by 1955. The value of school property was still 15 percent lower in black schools than white schools, and 15 percent of the black schools still had only one or two teachers compared to 4 percent for the white schools. This pattern of convergence in school characteristics across the racial systems in Maryland would signal similar convergence in human capital production across the racial systems starting in the late 1930's. Human capital production would not have completely converged by 1955 since there were still large gaps in some input levels between the black and white schools. Thus, the timing of the convergence in school characteristics is consistent with the convergence in black and white earnings reported by Smith and Welch (1978).

VI. Conclusions

This paper analyzed the factors underlying the observed differences in school attendance and achievement between black and white grade school children during the segregated era. The analysis utilized a model of demand

for schooling in which parents were assumed to derive utility from their child's academic achievement. It was shown that the school attendance decision depended upon the characteristics of the school, the child's wage and the parent's income.

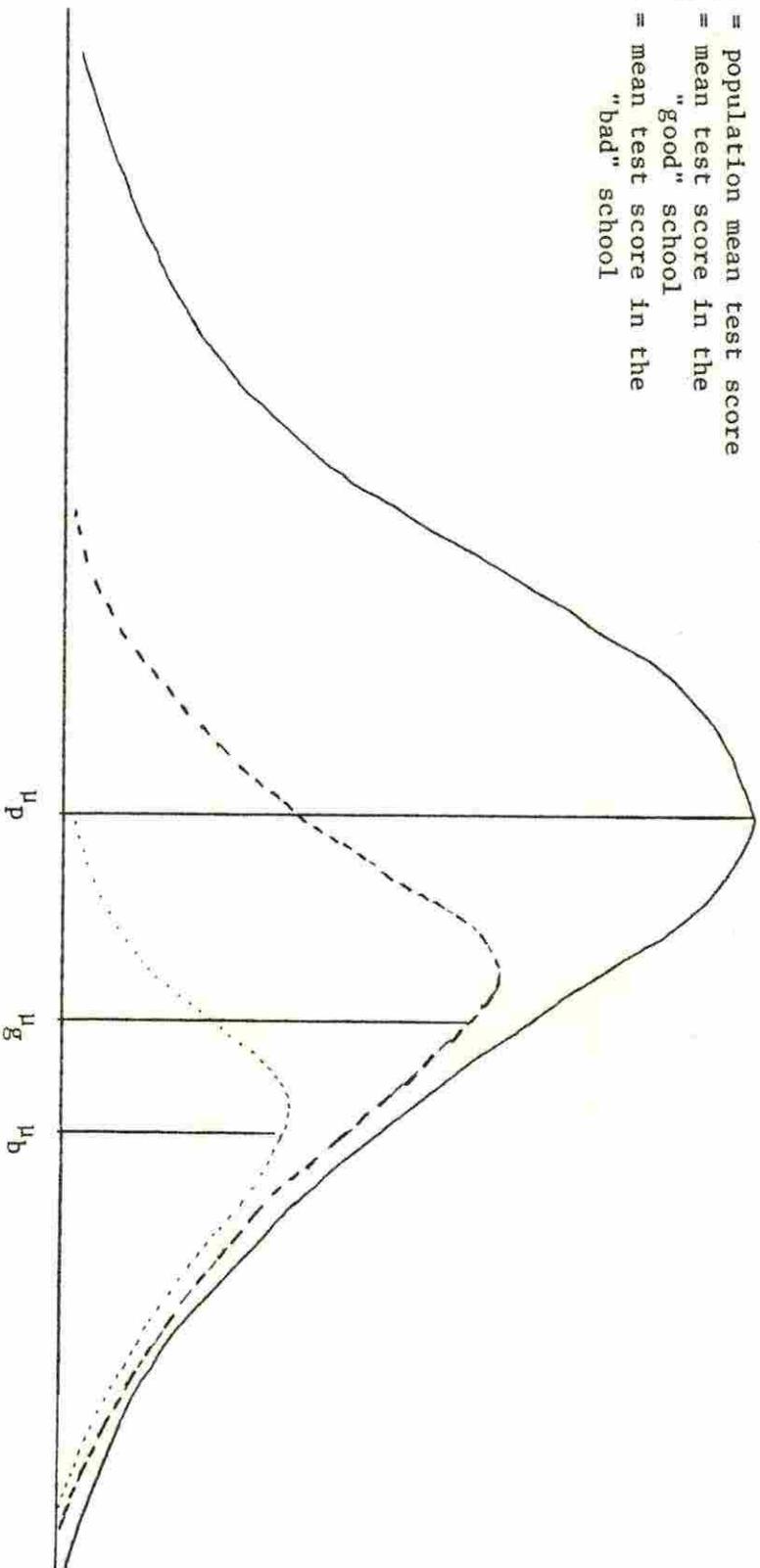
In addition, it was shown that the production process for school achievement and the demand for school attendance were not independent in two respects. First, there are sign predictions generated for the production process based upon knowledge of the parameters of the demand function and other sign predictions generated for the demand function based upon knowledge of the production parameters. Second, it was shown that if observation of the achievement measure is correlated with the school characteristics, the production parameters will be estimated with bias. A selection correction based upon the demand theory was introduced to correct the bias.

The model was tested on a sample of black and white segregated schools over the period 1924 through 1938. The theoretical predictions were borne out in the empirical work, giving substantial support to the theory. The selection bias was shown to be a significant factor in the data with the level of actual achievement in the schools being one-third less than the observed achievement level. The results show that, had school quality been equalized at the level in existence in the white schools in the period, both black attendance and achievement would have increased to the level of attendance found in the white schools.

These results support the view that school quality is an important factor in explaining earnings differences between blacks and whites educated prior to 1960. The predicted ratio of achievement levels in black schools to white schools in Maryland is similar to the ratio of schooling returns

for blacks and whites educated in the period. Because equalization of school quality in the period would have eliminated differences in human capital production between the black and white schools, these results suggest that the existing gap in returns to schooling for blacks and whites educated in the 1930's would also have been substantially reduced.

μ_p = population mean test score
 μ_g = mean test score in the
 "good" school
 μ_b = mean test score in the
 "bad" school



In both schools, the sample taking the test is not randomly selected from the population as a whole. The mean test score in both selected samples is greater than the true mean score in the population. The "bad" school selects out proportionally more low ability students, and so has a higher observed mean test score than the "good" school.

Figure 1. Distributions of test scores in "good" and "bad" schools having the same distribution of ability

Table 1^a. Empirical Definitions and Summary Statistics For Variable used in Estimating the Schooling Demand and Productions Equations

Variable	Definition	Black Mean	White Mean
<u>Endogenous Variables</u>			
ADA (D)	Average daily attendance in public grade school as a proportion of enrollment	.760	.826
TEST (P)	Proportion of students taking a standardized test of reading skills who meet or exceed the national norm	.22	.54
<u>Exogenous Variables</u>			
EXPI (D&P)	Proportion of teachers with at least one year of teaching experience	.95	.90
TERM (D&P)	Length of school term	168.9	185.4
CERT (D&P)	Proportion of teachers with at least a normal school certification	.86	.90
SMLSCH (D&P)	Proportion of schools with only one or two teachers	.90	.71
VALUE (D)	Value of school buildings and equipment per enrolled student	.056	.161
(P)	Value of school building and equipment per attending student	.07	.193
PTRAT (D)	Number of enrolled students per teacher	37.0	35.5
(P)	Number of attending students per teacher	27.9	29.4
WAGE (D)	Proxy variable for child wage. The measure used is the value of crop production per acre per county per year (1919 dollars)	.24	.24
ASSET (D)	Average value of farm land and buildings per farm per county per year (1919 dollars)	51.28	23.56
DUM31 (D)	Dummy variable equal to 1 for years preceding 1931.	----	----
CB (P)	Dummy variable equal to 1 for black schools	----	----

^a(D) signifies a demand variable and (P) signifies a production variable.

Table 2^a. Weighted Least Squares Estimates of grade school attendance equations for black and white children in Maryland, 1924-1938.

Variable	White	Black
EXPL	.0657 (4.13)	.0935 (1.65)
TERM/1000	-.645 (1.57)	.316 (.604)
VALUE	.0104 (.405)	-.0641 (.681)
PTRAT/100	.0732 (1.29)	-.2655 (3.87)
CERT	.1329 (12.59)	.0576 (3.49)
SMLSCH	-.0392 (2.92)	-.2482 (3.70)
WAGE	-.0380 (1.52)	-.1667 (3.62)
ASSET/100	.058 (4.64)	.007 (.544)
DUM31	-.0094 (3.01)	-.0516 (9.60)
Mean Fixed Effect	.7487 ^b	.9567 ^b
R ²	.85	.85
F	57.39	56.15
N	345	330
Mean of Dependent Variable	.8247 ^c	.7598 ^c

^at-statistics in parentheses. The dependent variable is the proportion of enrolled students in average daily attendance.

^bFixed effects significant at .01 level of confidence.

^cUsing the black mean school characteristics in the white demand function leaves predicted attendance virtually unchanged. Using white mean school characteristics in the black demand function increases predicted attendance to .8073. Following the imposition of the new truancy law, predicted black attendance evaluated at the white mean school characteristics rises to .8314 compared to .8304 in the white schools.

Table 3^a. Weighted Least Squares estimates of the educational production function for the pooled sample of black and white grade school children in Maryland, various years between 1924 and 1938.

Variable	1	2
C	-.26352 (1.158)	.1159 (.995)
CB	-.0886 (1.306)	-.2301 (7.223)
EXP1*ADA	.1654 (2.067)	.09987 (1.287)
TERM*ADA/100	.2396 (1.794)	.2093 (1.761)
VALUE*ADA	.5073 (3.317)	.4939 (3.180)
PTRAT*ADA/100	.0736 (.240)	-.2378 (.823)
CERT*ADA	.2027 (3.006)	.1416 (2.267)
SMLSCH*ADA	-.1707 (1.736)	-.1427 (1.44)
(1-Zξ)	1.002 (2.547)	----
CB*(1-Zξ)	-.7446 (2.364)	----
R ²	.74	.74
F	52.9	67.4
N	174	174
Mean Dependent Variable	.391	.391

^at-statistics are in parentheses. The years include 1924, 1928, 1932 and 1935 for white children and 1924, 1932, 1935 and 1938 for black children. The dependent variable is the proportion of students taking a standardized test of reading skill who meet or exceed the norm.

^bThe proportion of the entire school population which would meet or exceed the national norm had the exam been given to all the children in the school is predicted to be .264. This is 33 percent lower than the proportion meeting the norm in the population actually taking the exam.

Table 4^a. Weighted Least Squares estimates of the educational production function for black and white grade school students in Maryland, various years between 1924 and 1938.

Variable	White		Black	
C	-.0817 (.269)	.6465 (3.748)	-.4404 (1.152)	-.2184 (1.099)
EXPI*ADA	.1514 (2.231)	.1026 (1.500)	.4571 (.764)	.299 (.545)
TERM*ADA/100	-.1479 (.814)	-.3435 (1.959)	.318 (1.398)	.2906 (1.302)
VALUE*ADA	.4429 (3.301)	.4674 (3.352)	1.180 (1.86)	1.160 (1.841)
PTRAT*ADA/100	.7777 (2.204)	.3888 (1.146)	-.515 (.972)	-.484 (.920)
CERT*ADA	.3809 (4.792)	.2941 (3.841)	.0627 (.504)	.0444 (.368)
SMLSCH*ADA	-.0346 (.365)	-.0498 (.505)	-.251 (.674)	-.232 (.626)
(1-Z ξ)	1.284 (2.868)	-----	.3324 (.681)	-----
R ²	.64	.58	.30	.29
F	20.2	19.9	4.43	5.2
N	92	92	82	82
Mean of Dependent Value	.543	.543	.220	.220

^at-statistics are in parentheses. The years include 1924, 1928, 1932 and 1935 for white children and 1924, 1932, 1935 and 1938 for black children. The dependent variable is the proportion of students taking a standardized test of reading skill who meet or exceed the norm.

^bThe predicted proportion of the entire school population which would meet or exceed the national norm is .311 in the white schools and .150 in the black schools.

Table 5^a. Predicted proportion of the school population attaining or exceeding the national norm on standardized tests of reading skills for black and white students in Maryland, 1924-1938

	1924-1930	1932-1938	1924-1938
White	.2541 (.0961)	.3958 (.0499)	.3297 (.1031)
Black	.0668 (.1331)	.1764 (.1229)	.1252 (.1388)
Ratio of black to white	.26	.45	.38

^aStandard errors are in parentheses. These values were computed using the parameters of the production function in Table 3.

Table 6. Predicted mean scores for black and white children on a test with a norm of 50, given different values for the variation in test scores within black and white schools

σ_b	σ_w	μ_n	μ_b	μ_w	μ_b/μ_w
20	20	50	31.4	44.8	.70
20	10	50	31.4	47.4	.66
15	15	50	36.05	46.1	.78
15	10	50	36.05	47.4	.76

FOOTNOTES

*This paper is based on Chapter Four of my dissertation. I wish to thank my committee, Richard Murnane, T. Paul Schultz and Kenneth Wolpin for their many suggestions. Barry Falk, Wallace Huffman, J. Peter Mattila, Randall Olsen and Peter Reiss provided comments on earlier versions of this paper. All remaining errors are mine.

¹Welch (1973, 1980) and Smith and Welch (1977) are prominent proponents of this "vintage" explanation for the convergence in black-white average wages over the past two decades. This view has been challenged on two fronts. Freeman (1973) argues that increasing relative demand for black workers due to governmental action to reduce discrimination has caused the gap in black-white wages to narrow. Lazear (1979) contends that the narrowing gap is illusory, merely representing an exchange of higher entry-level wages for blacks for lower wage growth later in life.

²For instance, some teacher characteristic is usually found to be important in explaining achievement, whether it is experience (Hanushek (1972), Murnane (1975)), verbal ability (Hanushek (1972)), quality of the teacher's college (Summers and Wolfe (1977)), or the percentage of teachers with Master's Degrees (Brown and Saks(1975)). However, in some studies, teacher degree level makes no difference (Kenny (1980)), and teacher experience has a negative effect (Kenny (1980), Summers and Wolfe (1977)).

³This is particularly true earlier in the century when truancy laws were either weak or nonexistent so that attendance was subject to choice. However, attendance paths for high school students today presumably reflect the value of current schools in producing marketable human capital.

⁴In this analysis, number of children per parent is assumed fixed. An obvious extension of this analysis would be to consider the joint decision on quantity and quality of children.

⁵Here, the child wage in household work is assumed to be equal to the child wage in market work. Since the empirical work is based on a largely rural population, most child labor would be household or farm chores, either in their parents' or their neighbor's home.

Making child leisure endogenous does not change the results of the analysis and so was excluded (see Rosenzweig and Evenson (1977)).

⁶Parental time or purchased goods into the human capital production function are assumed to be the same, whether or not the child attends school.

⁷When A is one, we have the 'value added' function commonly used in the educational production literature.

⁸While this analysis assumes a specific functional form for Q , other functional forms are admissible. In particular, one could add quadratic terms in H and K_0 to allow for diminishing returns to these inputs. One could also include interactions between school and home characteristics. The former addition changes none of the predictions in (7). The latter complicates the sign predictions somewhat, but the general results still hold.

⁹The usual assumption that children attend full time implies that attendance is not correlated with the measures of school characteristics. Thus, the possibility of selection bias is assumed away.

¹⁰One likely candidate of such a selection effect would be the frequently observed declining trend in average SAT scores. Since the number taking the exam has risen over time, and the better students are most likely to take the exam in any period, declining SAT scores may merely reflect the inclusion of relatively more poor students in the larger test groups.

¹¹Following Olsen (1979), assume the v are distributed uniformly between 0 and 1. Let

$$E(v) = \mu_v = 1/2 \text{ and } E(v_i - \mu_v)(v_j - \mu_v) = \sigma_v = 1/12, i = j$$

$$E(u) = 0 \text{ otherwise}$$

$$E(u_i u_j) = \sigma_u^2, i = j \quad E(u_i v_j) = \rho \sigma_u \sigma_v, i = j$$

$$= 0 \text{ otherwise} \quad = 0 \text{ otherwise}$$

The conditional expectation of u given v may be written

$$E(u|v) = 2\rho\sigma_u\sqrt{3}(v-1/2) \quad (12A)$$

Substituting (12A) into (12) in the text, we get

$$E(Q|v > -Z\xi) = \beta SA + \delta H + \gamma K_0 - \rho\sigma_u\sqrt{3}(1-Z\xi)$$

which leads directly to the regression for (13) in the text.

If we assume the v have the standard normal distribution, we would get the Heckman (1979) correction. Olsen's method is much less expensive to estimate because it does not require maximum likelihood estimation. It also has the advantage of being easily aggregated over individuals.

¹²The assumption of the independent errors across days in the year may seem implausible. However, if the vector of Z variables is appropriately specified, the remaining error would be white noise. In actual empirical applications, it is likely that some factors will be omitted from the Z 's such as within year fluctuations in the value of child time due to seasonal agricultural demands for labor. It is not possible to predict how the omission of these factors will affect the estimated results. Since the required elements of the z vector are specified in the theory of schooling demand, inclusion of these variables in the empirical work should minimize the potential problem of aggregating over days in the year.

¹³Heteroskedasticity is caused by different sizes of population in each county and by the use of a linear model to estimate a dichotomous relationship. Weighted least squares may be used to increase the efficiency of the estimates. In this case, the weight involves multiplying by the square root of N and dividing by the square root of $P(1-P)$ where P represents the estimated probability of observing a "1" in the sample.

¹⁴Most selection corrections introduce heteroskedasticity into the second stage estimation due to the use of a dichotomous dependent variable in the first stage estimation of the probability of selection. Because our data is aggregated, our first stage estimation uses a continuous measure of the probability of selection rather than a dichotomous one, and so this problem should be less severe.

¹⁵For a detailed description of this data, see Orazem (1983).

¹⁶There were no black schools in Garret County in this period.

¹⁷Testing continued in later years, but efforts to locate the results of those tests proved fruitless.

¹⁸Smith and Welch (1978) report that the average attained level of schooling for the cohort entering the labor force in 1930 was 9.6 years for whites and 5.8 years for blacks. The proportion of the population with less than 9 years of schooling was 42 percent for whites and 78 percent for blacks. These figures are for the entire United States. Southern states generally lagged behind the national average in schooling, so the average years of attained schooling for Maryland are probably somewhat lower.

¹⁹There were two missing observations for black schools in 1924 and 1932. Two observations were excluded in 1938 as outliers, Anne Arundel and St. Mary's counties.

²⁰We aggregate over the enrollment population N in the demand equation, but only over the attending population n in the production equation.

²¹Normal school is a two year teacher's college.

²²The use of a measure of the value of child labor in agriculture stems from the rural nature of Maryland population at the time (the U.S. Census designates 67 percent of the population as rural) and because of the exclusion of Baltimore City from the sample. The correlation between the proxy measure of wages at the state level and an index of agricultural wages was .94.

The movements in the value of agricultural output may represent changes in the supply of child labor rather than changes in the demand for child labor. If, for some reason, more children are available for agricultural production in some years than other, the increase in child labor supply may increase production and thus increase the value of output per acre.

²³A more complete model with parental leisure and hired labor would allow substitution of alternate labor for child labor.

²⁴Notice that because the Z 's enter the production function linearly, the selection correction requires that the Z 's not be a subset of the regressors in the production equation. Without these identifying restrictions, the Z 's and the S 's would be perfectly collinear, meaning that the covariance matrix would not be of full rank.

²⁵Even if it existed, an aggregate measure of past achievement in the school may be inaccurate. The higher the movement of students into and out of the school (through migration, graduation or truancy), the greater the error in the measure of current stocks of human capital.

²⁶Weighted least squares were used to correct for potential heteroskedasticity. See note 7.

²⁷For the pooled sample, the F-test was $F(22, 142) = 1.30$. For the white sample, the F-test was $F(22, 66) = 1.709$. For the black sample, it was $F(21, 53) = 1.33$.

²⁸The average SAT scores would be one example of such a selected measure of student achievement.

²⁹The strong effects of school quality on achievement in this study are similar to the current findings in lesser developed countries. Heyneman and Loxley (1982) find that the poorer the country, the higher the impact of school quality on achievement.

³⁰The positive sign on PTRAT is perhaps surprising since the presumption is that students benefit from smaller class sizes. However, there is no reason why schools should not be subject to scale economies, particularly if students benefit from interaction with their peers as well as their instructors. Interestingly, most studies of achievement in recent periods have found no effect of pupil-teacher ratios on learning. On the other hand, Welch (1966,1967) found significant positive effects of pupil-teacher ratios on income. A similar approach used by Rizutto and Wachtel (1980) found positive but insignificant effects of pupil-teacher ratios on earnings.

³¹The missing observations for some of the black county school systems signal a lower level of care in the administration of tests for black children.

³²Some feeling for what a "reasonable" value for the standard error is can be obtained by noting that 95 percent of the area of a normal curve lies within two standard deviations of the mean. If $\sigma = 20$, then 95 percent of the scores lie between 10 and 90.

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