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ABSTRACT

In the direct and indirect effects of teacher characteristics on educational production of students over time, this study indicates that teacher characteristics were not critical determinants of student achievement. Characteristics include: experience, educational level, recentness of degree and degree nature, college quality, and other background. Positive indicators across the student sample groups were that the percentage of non-white teachers was the only consistently performing characteristic. After a review of the literature of cross sectional and longitudinal analyses, the present longitudinal model of educational production is discussed. Data, empirical results and structural equation estimates for the 3 sample groups are presented. Results within the operational five-period model are followed by conclusions and implications for theory and practice. An appendix of eleven steps in the data procedures is included. (CM)

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A Longitudinal Study of Determinants of Educational Achievement

Final Report: NIE Grant #G-78-0059

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CONTENTS

CONTENTS (continued)

CONTENTS (continued)

Appendix

TABLES

TABLES (continued)

TABLES (continued)

FIGURES

Chapter 1

REVIEW OF THE LITERATURE

One of the most critical issues facing public education today concerns the effectiveness of schools. To many individuals an effective school is one which provides training in basic verbal and mathematical skills as well as in advanced subject areas necessary for the smooth functioning of a complex, technological society. In addition to cognitive skill training, schools may influence their students' values and attitudes by emphasizing achievement, competition, and certification. As the sociologists Blau and Duncan (1967), Kamens (1971), and Sewell, Haller and Ohlendorf (1970) point out, one's position on the occupational, economic, and prestige ladders of society is determined largely by schooling (Spady, 1973:135). Economists have largely substantiated these findings by demonstrating that achievement and years spent in school are powerful predictors of earnings in the labor market (see the reviews by Mincer (1970) and Rosen (1977), and also Weisbrod and Karpoff (1968), Weiss (1970), and Hansen, Weisbrod, and Scanlon (1970)). Recent research by Taubman (1976) utilizing data on identical and fraternal twins suggests, however, that schooling may be somewhat less important than the studies mentioned above imply.

Two critical issues which this study will particularly address are (1) Do measurable differences in school resources, particularly characteristics of teachers, signify measurable differences in student outcomes? (2) If measurable differences exist, are the benefits commensurate with the costs? In attempting to answer these questions a review of past studies of education production relationships in elementary and secondary public schools will be undertaken. Each study addressed in the review employs an input-output research approach where it is generally assumed the output is student achievement and the inputs are student ability, family background, peer influences, and formal school resources.

A thorough understanding of the process which translates family, peer and school resources into achievement requires explicit information on the ability of the student, his previous and current level of achievement, his motivations, his non-school environment, and his current and past school resource inputs - facilities, programs, teacher and classmate characteristics.[1] Inclusion of a previous level of achievement implies the model is measuring the amount of achievement gain which occurs as a result of exposure to a fixed set of school resources. The omission of prior school resource inputs presumes either that past exposure to school resources will be reflected in earlier achievements or that there is a rapid decay of benefits from previous school resources (i.e., the second grade instructor's influence will be felt only in grade two). This latter point is important since most of the studies discussed below omit consideration of previous school resource inputs. Before the actual studies are explicitly

[1]See Hanushek (1968), Armor (1972), and Levin (1970) for a complete discussion.

discussed three key problems which no study can completely ignore require elaboration.

1. Attempts to determine whether measurable differences in school resources imply measurable differences in student outcomes have been hampered by lack of adequate data. The substantial heterogeneity in the characteristics of students, teachers, and organizational features across schools makes adherence to stringent research requirements difficult. At the same time homogeneity prevails within schools; teachers and students with similar attributes self-select into schools with certain facility and instructional characteristics. The high correlation between student characteristics and school resources creates a serious problem in the analysis and interpretation of the data. As shall be discussed subsequently, the problem is particularly troublesome when stepwise regression is the statistical technique employed.

2. An additional consideration is raised when one attempts to determine causality (Spady, 1973:135-136). Mere existence of a statistical relationship between a school resource such as teaching experience and student performance does not mean experience directly affects performance. For example, it is possible that as teachers accumulate seniority they may transfer to schools with high performing students providing a false positive relationship between experience and performance.

3. Although cognitive development is a widely accepted objective of public education, several problems arise when only one output

is examined. Inputs which effectively produce achievement may be inappropriate for the production of student motivation or imagination. If priorities for an output vary among schools, production function estimates of the relationship between any single output and school resources will be distorted. The relationship becomes even more complex if the objectives of schools vary systematically with the socio-economic composition of their student bodies. For example, secondary schools for middle and upper class students are generally thought to be more academically oriented than secondary schools for lower class students which emphasize vocational curricula. If such a relationship exists, statistical analyses using the socio-economic background of the student body will confound social class with relative emphasis on academic skills. In this case the statistical importance of social class influences will be exaggerated in estimating achievement scores while the effect of school resources will be understated (Levin, 1970: 56-57).

Input-output research in education occurred prior to the publication of Equality of Educational Opportunity, or EEO, by Coleman et al. (1966). In terms of the sheer volume of debate and scrutiny of methodologies EEO generated, however, it stands out as a landmark study. The most relevant criticisms of EEO will be highlighted as examples of methodological shortcomings inherent in most of the cross-sectional literature.[2] A discussion of additional cross-sectional

[2] Many of the criticisms discussed can also be found in Bowles and Levin (1968a, 1968b), Bowles (1969), Hanushek (1970), Michelson (1970), Levin (1970), all of the contributors to Mosteller and Moynihan (1972) - particularly Hanushek and Kain, and Spady (1973).

studies, including the reanalyses of EEO, will follow. The last section of this review will be devoted to the longitudinal analyses.

Cross-Sectional Analysis: Equality of Educational Opportunity

Equality of Educational Opportunity was originally commissioned as a survey to determine if minorities were being discriminated against in access to public education. It quickly developed into an in-depth analysis of the educational production process. This development was, in part, a natural outgrowth of at least two possible definitions of equality which arose: (1) equality of resources of school inputs, and (2) equality of achievement or ouptut of the educational process (Hanusheck and Kain, 1972:117). EEO probed into both definitions but concentrated on educational achievement, estimating a statistical model which related school and student characteristics to achievement test scores.

The conceptual model outlined in EEO and many subsequent studies was of the following general form:

(1-1) $A_{it} = g(F_i(t), P_i(t), I_i, S_i(t))$

where A_{it} = vector of educational achievement of the ith student at time t

F_i = vector of individual characteristics and family influences cumulative to time t

P_i = vector of peer influences cumulative to time t

I_i = innate ability of the ith student

S_i = vector of school influences relevant to the ith student cumulative to time t.

The model states that the achievement of the ith student at time t, (A_{it}), is some function (g) of his characteristics and family influences (F_i), of his peer influences (P_i), of his innate ability (I_i), and of the quantity and quality of school inputs, (S_i), made available to him cumulative to time t (Hanushek and Kain, 1972:123).

Lacking data on past inputs, innate ability and previous achievement, EEO was only able to utilize crude measures of non-school environments, current school resource inputs, and current achievement. Innate ability was omitted from the statistical models although its presence may have been felt through the variables measuring socio-economic status.[3]

The most striking conclusion of the study concerned the quantity and quality of school inputs.

> The first finding is that schools are remarkably similar in the way they relate to the achievement of their pupils when socio-economic background of the students is taken into account. It is known that socio-economic factors bear a strong relation to academic achievement.

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[3]It does not seem unreasonable to assume that innate traits have some component which is reflected in the vector of family background characteristics. Even if the genetic relation between parental traits and a child's innate ability is minimized, other transmission mechanisms are possible. Alter and Bittner (1974) have shown that a child from a low socio-economic class is more likely to be a candidate for prenatal protein starvation, a factor which diminishes mental ability. Other evidence documenting the relationship between ability and environmental influences can be found in: Johnson (1963), Vandenberg (1966), and Scarr and Weinberg (1976). Contrasting views on the extent to which innate traits are genetically determined can be found in: Hunt (1961), Jensen (1969), and Stodolsky and Lesser (1967).

> When the factors are statistically controlled, however, it appears the differences between schools account for only a small fraction of differences in pupil achievement. (Coleman et al., 1966:21.)

The crucial variables in the production of achievement were home environment and the student's peers. School facilities, curriculum and teacher quality[4] did show some relationship to student achievement. In particular, teacher effects were progressively greater at higher grades, implying a cumulative impact of the qualities of teachers in a school on student achievement (Coleman et al., 1966:22). The overall impact of teacher characteristics, however, was dwarfed by the explanatory power of the home environment.

EEO's conclusions regarding the relationship between school resources and student achievement are difficult to interpret for numerous reasons.

1. The relationship between current and past achievement and current and past resources is unclear (Spady, 1973:138-139). A pupil's achievement at the end of grade eight may be influenced not only by the instruction he received during that grade, but also instruction in prior grades. EEO's inferential finding of a cumulative impact of teacher quality on student achievement suggests this very situation. When past resource and achievement variables are absent from a statistical model, current achievement is assumed to be a function only of current resource allocations. Even if prior achievement measures are

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[4]Teacher quality was measured by verbal ability test scores, level of education and parents' education.

utilized, the extent to which previous instruction influences prior and current achievement remains unspecified.[5] These omissions would tend to underestimate the total effects of instruction. The effects of the more accurately measured background factors, however, are always overstated when compared to the poorly measured school inputs.[6]

2. The statistical methodology utilized in EEO differed considerably from what was implied by the general conceptual model. The variance in achievement was partitioned among sets of explanatory variables (roughly the vectors in Equation (1-1)) by using a technique known as stepwise regression. The conclusions of EEO were then based upon the amount of variance explained by each vector as it was entered in the regression equation after the family background vector. This procedure was justified on the grounds that a pupil's background was "...clearly prior to, and independent of, any influences from school factors" (Coleman et al., 1966:330). The clear contribution of school resources to achievement, over and above the effect of the family background, could thus be determined.

Unfortunately, this type of analysis of variance procedure is straightforward only if the vectors are uncorrelated. Many of the independent variables used in EEO were correlated. For example, more highly educated parents may weigh school quality more heavily than

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[5] See Boardman and Murnane (1979) for a complete discussion of the biases underlying such models.

[6] A detailed discussion of the over-estimation of the background factors can be found in Bowles and Levin (1968a), Hanushek and Kain (1972), and Luecke and McGinn (1975).

less educated parents when making residential location decisions. Interpretation of the regression equation has now become more complex; only a portion of the explained variance can be assigned uniquely to each vector. Two sets of vectors, family background and school quality, now jointly explain a portion of the variance. Since only the increment to explained variance (R^2) is assigned to each newly added vector, the proportion of variance assigned depends critically on the order of entry in the regression equation. When two vectors are correlated, the first vector entered will be assigned both its unique contribution to the explained variance and its jointly explained variance with other vectors. By always entering the family background vector first,[7] the authors assured that the joint variance explained by family and school vectors would be assigned to the family vector. Part of the joint variance may have been due to prior background influences, yet the cross-sectional nature of EEO prevented it from disentangling the various prior effects. The net result of the statistical procedures was to bias the case against school inputs (Hanushek and Kain, 1972: 124-126).

3. The third major problem in interpretation of EEO's findings

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[7]It should be noted that the problem would not be solved by merely reversing the order of vectors. If the school vector were entered prior to the home vector, the increment to R^2 would include its unique contribution and its joint contribution with other vectors. This problem of interpretation has caused many authors - Goldberger (1964), Darlington (1968), Cain and Watts (1968), Duncan (1970) and Johnston (1972) - to argue against any attempts to partition variance when input vectors are correlated. On the other hand, Mood (1971) argues that you partition and show how much variance is explained by intercorrelation of the vectors or sets of vectors.

concerns the level of aggregation. There are three components to the aggregation problem; the first concerns the unit of analysis. As in many subsequent cross-sectional studies, the unit of analysis was neither the student nor the classroom, but the school. While the achievement test score corresponds to the individual student, variables such as teacher experience or level of education are averaged over all the instructors in the student's school. This aggregation means that the school variables can only explain the achievement variance between, not within, schools. In the EEO data the variation in achievement between schools accounted for only 20 percent of the total variance (Coleman et al., 1966:23). The remaining 80 percent, variance in achievement levels within schools, could not be explained by the school resources.

Aggregation also introduces measurement error in the estimating equations. For example, school facilities were assumed to be equally utilized by all students, but an item like a science laboratory has little relevance to students enrolled in a secretarial program. Measurement error is thus most severe in large junior and senior high schools with diverse programs and in schools where students are tracked according to their ability. Students in the same school make radically different use of educational resources.

The variables representing peer influences were also aggregated at the school level. Lacking data on specific classrooms, peer influences were measured by the proportion of the school's pupils whose families owned encyclopedias and the proportion planning to attend college. The problems associated with this variable lie more in the interpretation than in the actual aggregation. If families with minimal budget constraints and/or strong preferences for education systematically locate in neighborhoods with better schools, student body characteristics will be highly correlated with real differences in school resources. Under these circumstances, student body characteristics may actually be proxy measures of the quantity and quality of school resources. While this conjecture cannot be confirmed using EEO data, it is certainly true that some portion of the "uniquely" explained variance attributed to family and student body variables could reside with the school inputs (Hanushek and Kain, 1972:131-132).

4. The omission of innate ability,[8] while probably inflating the importance of both school and family background variables, particularly overstates the significance of the family variables. If innate ability is uncorrelated with other explanatory variables included in the model, its absence will simply increase the size of the error term (reduce the variance explained by the model). If genetic inheritance is in any way responsible for innate ability, however, the influence of that ability will be partially represented by the family background vector measured for each student. If innate ability can be modified

[8] In an ideal sense, we would like innate ability to measure "potential" or "capacity for learning" and achievement to measure "attainment." The practical difficulty of measuring potential at the moment of birth and its constancy over time has led to an extensive literature concerning the genetic and environmental influences on ability (as is measured in IQ tests); see footnote 3.

a possible positive correlation between teaching inputs and innate ability (Hanushek and Kain, 1972:129). Family background variables are therefore overstated to a greater extent than the school resource variables.

5. A linear additive specification of educational production was utilized by EEO and by all the other cross-sectional studies considered in this review.[9] A linear additive specification assumes that each unit of a particular resource contributes a constant amount to student achievement. The unit contribution of any one input does not vary with the total amount of the input received, nor with the amounts of any other inputs (Goldberger, 1968:108-109). Operationally this assumption means that the unit contribution of a variable like teaching experience has the same impact on student achievement when the change is from zero to one years as when it is from 15 to 16 years. It further states the contribution is identical across student characteristics.

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[9] The variety is somewhat greater than is implied by this statement. As Hanushek (1979) notes, several authors, including Coleman, stratified samples by race or socio-economic background and estimated linear or logarithmic models within stratifications (Hanushek, 1972; Smith, 1972). General covariance analyses which allow for a variety of functional forms in terms of underlying descriptions of teachers have also been conducted (Hanushek, 1972; Murnane, 1975). A variety of interactions among variables have been introduced (Murnane, 1975; Winkler, 1977; Summers and Wolfe, 1977). The point was made to illustrate that EEO and most of the cross-sectional literature which followed it left unexamined the curvilinear and interaction effects that may have existed in the data.

by environmental influences, including that of the school, the school inputs utilized in EEO are least likely to reflect such a correlation. The averaging of the teacher characteristics over the school obscures

While there is not much guidance about the appropriate functional form, intuitively one might expect declining marginal products and complementarity among inputs. By failing to incorporate squared or interaction terms in the model, EEO ignored these possibilities.

EEO's "striking" conclusion that the quality or quantity of school inputs had little or no effect on student achievement seems considerably less striking in light of the above criticisms. Only 20 percent of the total variance was "explained." Failure to consider past inputs, utilization of stepwise regression, the existence of measurement error particularly on the school inputs, and the omission of innate ability probably biased downward the impact of the school resources.

Reanalyses of EEO

Several reanalyses of EEO data were conducted in an effort to minimize these problems as well as to further investigate the impact of school resources on student achievement. The reanalyses of EEO data occurred across geographical and racial subsamples. Although Mayeske et al. (1969) reanalyzed the total EEO sample, most of the reanalyses concentrated on the sixth grade sample since the methodological shortcomings were least severe for elementary students.[10]

The most interesting finding of the reanalyses centered around

[10] Detailed criticism of the third, ninth, and twelfth grade data can be found in: Armor (1972), Hanushek and Kain (1972), Jencks (1972), Levin (1970), and Smith (1972).

the characteristics of teachers. Teaching characteristics were statistically significant predictors of achievement, particularly black achievement, although the magnitude of their effect was small (Spady, 1973:141-142). A detailed discussion of Hanushek (1968, 1970) will illustrate the latter point more clearly. Hanushek did not want to assume the production process operated identically across racial lines; thus, he estimated the production of mathematical and verbal achievement separately for blacks and whites. The unit of observation was the school; the output measures were mean sixth grade scores on math and verbal achievement tests. The teaching inputs were degree level, experience and verbal ability[11] averaged over all the teachers in the school at the time of the survey. Hanushek reported that substantial migration of teachers and students had occurred in the schools under study. Errors in variables resulted, causing a downward bias in the coefficients on the school inputs (Murnane, 1975:11-13). Despite this bias, the coefficient on average teacher experience was positive and significant in all of the equations. The relationship was particularly strong in the black equations. The coefficient on teacher verbal ability was a significant, positive predictor of black verbal achievement but insignificant in terms of black mathematical achievement. The teacher's degree level was insignificant for both races.

Hanushek's findings were substantiated by Smith (1972) who

[11]The verbal ability score is being generalized here to represent the intelligence level of the teacher. The relationship between verbal ability and personal attributes can be found in John C. Flanagan et al. (1964:Chapters 7-8).

found that teaching characteristics accounted for a larger unique proportion of achievement variance in blacks than whites. His findings on degree level and experience also paralleled Hanushek's but the coefficient on teacher's verbal ability was insignificant. Armor (1972) demonstrated that the above results were not specific to northern metropolitan areas but held also in the south. Southern black verbal achievement varied more with the characteristics of their instructors and schools than any other group in the EEO sample. The Mayeske et al. (1969) reanalysis of the total sample supplied additional confirmation of the above findings. The unique effect of family background on achievement was greater for students of high socio-economic status; the joint school and background effects were greater for students of low socio-economic status.

Two exceptions to the overall pattern of differential race effects emerged in studies by Michelson (1970) and Guthrie et al. (1971). Michelson, utilizing a three-equation model to allow for the simultaneous determination of attitudes and achievement, found teacher experience and verbal ability to be significant predictors for whites but insignificant for blacks. In a similar vein, Guthrie et al. found more significant correlations between school resources and student achievement when the students came from high socio-economic status (SES) deciles. Their sample was divided on the basis of SES deciles and the relationship between each school resource and verbal achievement was examined one at a time within the decile. Variables found to be important in isolation, however, might have proved insignificant if analyzed simultaneously with related variables (Spady, 1973:143-145).

The reanalyses illustrate that certain teaching characteristics positively influence achievement, although the magnitude of the effect is small. Unfortunately the findings are not consistent across the studies. A possible explanation for the small size of the coefficients may be in the limited variance of the racial and regional subsamples. Subgroups of students and teachers will exhibit less variation on the variables measured than if compared to their peers in other localities. The uneven impact of teaching characteristics across races is much more difficult to understand.

Related Cross-Sectional Analyses

In addition to EEO and its various reanalyses, other cross-sectional studies arose attempting to explain the relation between school resources and student achievement. Reviews of some of these studies appear in Guthrie et al. (1971), Averch et al. (1972), Cohn (1975), Spady (1973), and the October 1979 issue of Educational Leadership. Rather than reiterate these reviews, this section will be limited specifically to those studies which emphasize teaching resources.

Many of the studies discussed below utilize per pupil expenditures as an explanatory variable. The relationship between expenditures, salaries, and teaching characteristics should thus be made explicit. Per pupil expenditures usually include funds for equipment and supplies as well as for staff salaries. Roughly 65 percent of these expenditures are devoted to teacher salaries (Kahn, 1974:20). Per pupil expenditures will thus be a partial proxy for teacher salaries. Salaries, which vary across districts, are determined by such factors as experience, level of education, merit raises and fringe benefits. Studies which utilize per pupil expenditures or salaries will thus, in part, be capturing the teacher "quality" variables of degree and years of experience.

In a nationwide sample, Mollenkopf and Melville (1956) controlled for socio-economic status and found mean student achievement to be consistently related to library and supply expenditures per student, low pupil-teacher ratios, small class size, and number of special staff in the school (psychologists, reading specialists). Many of the problems inherent in EEO arose in this survey, particularly the problem of selective response bias. Only 506 principals, out of the 1,877 schools selected, replied to the questionnaire and agreed to execute the achievement tests. Further, the most significant school resource, library and supply expenditures per pupil, may have been proxying for some other school, non-school, or peer group attribute.

Goodman (1959) also found special staff and per pupil expenditures to be important for seventh and eleventh graders in New York school districts. Controlling for socio-eocnomic status, mean seventh grade composite achievement was positively associated with the percentage of teachers in the district with over five years of training. The partial correlation was .37. When analyzed in isolation, per pupil expenditures and special staff were second and third in order of importance. The high correlation between expenditures, training, and special staff precluded their being analyzed simultaneously. Nonetheless, it appeared experience was the most significant predictor of achievement.

Kiesling's (1967) reanalysis of the same data did not produce similar conclusions. Classifying the districts on the basis of size, he found a strong positive association between per pupil expenditures and achievement in districts with greater than 2,000 (mostly disadvantaged) pupils. In smaller districts, the association was random and sometimes negative.

Kiesling's (1969) study of fourth to sixth grade achievement gains in 97 New York districts was more sophisticated, yet again no association was found between per pupil expenditures and achievement in small, rural districts. Further clouding the issue, a negative association was found between per pupil expenditures and achievement in urban districts. The negative finding was consistent with Benson et al.'s (1965) results for urban California districts, yet inconsistent with Kiesling's earlier work and with findings by Armor (1972), Mollenkopf and Melville (1956), and Goodman (1959). Benson et al.'s (1965) results on rural districts did not confirm Kiesling either. In districts with less than 4,500 pupils, mean teacher salaries were positively related to student achievement (Spady, 1973:146-147).

Burkhead (1967) examined the relationship between school resources and outputs in 39 Chicago public high schools. His models took the form:

(1-2) $EA_i = f(HE_i, SE_i)$

where EA = proportion of students in a school scoring above the 40th percentile on eleventh grade IQ and reading tests

HE = median family income for the school

SE = vectors of school resource characteristics including: median teacher experience, proportion of teachers with Master's degree or higher, textbook expenditures per pupil, material and supply expenditures per pupil.

Following the statistical methodology of Coleman et al. (1966), the family background vector was entered first. This vector thus reflected any variance which could have been explained jointly by the family and school resource vectors. Median family income yielded an R^2 of .81; the addition of the school resource vector raised the R^2 to .86.

An additional study involving Burkhead, Fox, and Holland (1967) employed data from Chicago, Atlanta, and the original Project Talent sample.[12] The level of aggregation of problem inherent in EEO arose in this study; the school to school variation in achievement represented

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[12] Besides the Office of Education Survey, Project Talent collected survey data from a nationwide sample of students. Roughly 400,000 students from 987 schools received the questionnaire. As Winkler (1977:78) discussed the Talent data differs from the Report data in:

1. Only secondary school students were considered.
2. No information was directly collected from the teachers, although school principals were administered questionnaries.
3. Follow-up questionnaires were planned.
4. Race information was not gathered in the initial survey, but did appear in a follow-up questionnaire.
5. More extensive data on student attitudes, aptitudes and achievement was collected.

the upper limits of the effects that could be attributed to the school resources. Additional problems were created because the achievement tests were not similar across cities. Teaching resources were significant, but the signs on the coefficients were sensitive to the particular sample tested. In Chicago, teacher experience was negatively related to pupils' reading scores. Teacher experience was positive in the Project Talent sample and more significant than the positive impact of starting salaries. Median teacher salary was positive but not significant in Atlanta.

Three additional studies found teacher salaries to be important predictors of achievement. Cohn (1968), controlling for socio-economic status, found median teacher salaries to be positively associated with increments in achievement in Iowa high school districts. Number of teachers' college credit hours was negative, however. Averch and Kiesling (1970) reported similar results using Project Talent data. Raymond (1968) examined average scholastic achievement by county from a sample of 5,000 West Virgina high school students who went to West Virginia University. The output measures utilized were freshmen college scores on the American College Test (ACT) and grade point average. The county of pre-college attendance determined the school inputs. Raymond attempted to determine if the quality of elementary and secondary school teachers influenced either of the output measures. Using county census data to control for students' socio-economic status, teacher salary was the most important predictor of both outputs. Elementary school salaries were particularly powerful, possibly implying the existence of a lagged relationship between teachers' characteristics and student performance.

We now turn to those studies which look at more specific teacher characteristics. Bowles (1969) looked at black male twelfth graders from the Project Talent sample. The percentage of teachers in the student's school with graduate training, small class size, and expenditures per student on non-teaching inputs were positively associated with reading and mathematics achievement. However, only class size was significant at the .05 level.

Katzman (1968) investigated the production of six school outputs across 56 elementary districts in Boston. The output measures included median fifth grade math scores, median increments in reading scores from the second to the sixth grade, two measures of school attendance, and the percentage of students in each district who took and passed the entrance exam to Boston's pretigious Latin school. The percentage of permanently employed (tenured) teachers had a positive impact on five outputs, but a slightly negative influence on the increments in reading achievement. Two characteristics associated with teachers' salaries, the percentage of teachers in a district with one to ten years of experience and the percentage of teachers with a Master's degree, were even more inconsistent; both variables were positively associated with school attendance measures, but negatively related to reading increments. The percentage of annual teacher turnover had a negative association with all output measures.

Levin (1970)[13] was particularly concerned that a single equation model would lead to biased and inconsistent estimates on the resource inputs. He pointed out that student attitudes, besides being important inputs, were also important outputs in the production of cognitive achievement. Conceptually, achievement (A) would be a function of student attitudes (N), innate ability (I), school resources (S), and influences external to the school (F), or:

(1-3) $A = f(I,F,S,N)$.[14]

Since he postulated achievement also influenced attitudes, a second equation was required, or:

(1-4) $N = f(A,I,S,F)$.

The interdependence of the independent and dependent variables implied the values must be solved simultaneously to produce unbiased estimates; two-stage lease squares was thus employed.[15] Levin utilized EEO data

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[13]Much of the work described can also be attributed to Samuel Bowles. Although this particular study was published by Levin, other similar studies were published by Bowles (1969, 1970) and the two jointly - Bowles and Levin (1968a, 1968b).

[14]This example is only illustrative; a complete specification requires a separate equation for each of the endogenous variables.

[15]Bowles approached the interdependency problem differently; he solved the system of simultaneous equations for the reduced forms. Each endogenous variable was thus expressed as a function of the exogenous variables. Ordinary least squares then gave consistent estimates of the parameters. Using EEO data, he compared reduced form and structural equation estimates. In contrasting the two sets of estimates, little difference was found in the values of the coefficients on the school inputs.

from an eastern metropolitan area and was extremely careful in his construction of the school inputs. To minimize measurement error which would result from residential mobility,[16] Levin considered only those students who received all of their education in the school they were currently attending. Teacher characteristics were averages across the third and fifth grade instructors in each school. While average teacher degree level had no significant relationship with verbal achievement, average teacher experience was strongly positive. Levin found also that teacher's verbal ability and institution of undergraduate training were insignificant predictors of student achievement.

Longitudinal Analyses

Four longitudinal studies of educational production relationships, Hanushek (1971), Murnane (1975), Winkler (1977) and Summers and Wolfe (1977), will now be examined. The studies are classified as longitudinal because each employs data which cover more than a single year. In addition, three of the studies utilize data where students are matched to their respective teachers. The problem of obscuring the relationship between achievement and teaching characteristics by excessive aggregation is thus avoided.

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[16] The estimated effect of school inputs on achievement will be biased downward if the school inputs assigned in September or October do not reflect school inputs in previous years. Hanushek and Kain (1972:130-131) argue that the problem of a spurious correlation is even more critical for blacks since they have a higher mobility rate than whites.

The importance of formal teacher credentials, experience and graduate education can be partially seen in the rigorously derived results of Hanushek (1971). One of the strongest points of Hanushek's work lies in his explicit development of a conceptual model of the educational production process. The model stated in the opening sections of this review,

$$(1\text{-}1) \quad A_{it} = g(F_i^t, P_i^t, I_i, S_i^t) ,$$

was first discussed in detail by Hanushek in his 1968 doctoral dissertation. Recognizing the problems posed by the omission of innate ability and previous school inputs, he included a measure of past achievement in the estimating equation. A model with previous achievement thus measured the "valued-added" of the current school inputs. Hanushek argued biases would occur only if the missing portion of innate ability was correlated with the rate of learning (as opposed to the level). The portion of innate ability that was inherited would be captured by the family background variables.[17] Difficulties in interpreting school resource effects would not arise unless there was a mechanism connecting the "non-hereditary" portion of innate ability with specific school resources.

The basic sample consisted of third graders from a large school

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[17] The family background variables will capture the inherited portion of innate ability only if social mobility is correlated with ability. The above situation thus may not hold for blacks.

system in California. If data were not available on the second or third grade instructors or on the first and third grade achievement scores, the student was dropped from the analysis. Missing data thus reduced the total sample of 2,445 students to 1,061. The sample was then stratified on the basis of race (white vs. Mexican-American) and father's occupation (manual vs. non-manual). The stratification was justified on the grounds that the proxies for the background inputs might not have the same meaning across races. There also appeared to be no a priori reason to insist on the same model of the educational process for both groups. The following equation was used to estimate the white, manual ($n = 515$) and white, non-manual ($n = 323$) samples.

$$(1\text{-}5) \quad A_{j3} = a_0 + a_1A_{j1} + a_2F + a_3R + a_4T_3 + a_5T_2 + u$$

where: A_{j3} = achievement of jth student grade three

A_{j1} = achievement of jth student grade one

F = dummy variable for female student

R = repeat grade: = 1 if grade repeated, 0 otherwise

T_2, T_3 = second and third grade teacher characteristics (experience, hours of graduate education, verbal ability score, years since most recent educational experience, and years of experience with a particular socio-economic level).

Experience and hours of graduate education were statistically insignificant for second and third grade instructors in both samples. The characteristics which were determined to be significant varied slightly across the samples. Second and third grade instructors' verbal score and recentness of educational experience were important predictors of third grade achievement for the white, manual sample. In the white, non-manual sample, recentness of educational experience was again important but "experience with this socio-economic group" replaced verbal score as a significant variable. Teacher characteristics did not appear to be important for the Mexican-American sample.[18] Hanushek reasoned this was probably due to a language barrier, yet it may have resulted from the small sample size (n = 140).

An analysis similar to Hanushek's was conducted by Murnane (1975) using two cohorts of elementary black students from New Haven. Both cohorts contained approximately 440 pupils, yet only one covered a two-year period. Progress in reading and mathematics was measured

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[18] Hanushek tested for measured and unmeasured teacher characteristics by constructing a series of dichotomous variables, T_{ij}, for each instructor in the sample. Regression analysis was then utilized to explain third grade achievement in terms of teachers. If the jth student had the ith teacher, T_{ij} equaled 1 for him and T_{ij} equaled 0 where $k \neq i$. Thus:

(1) $A_{i3} = t_i T_{ij} + aF_j + bA_{j2} + u_j$

where t_i, a, b = estimated regression coefficients. This approach made it possible to test whether the classroom coefficients were significantly different from a constant, or whether real differences existed among teachers in terms of their contribution to performance gains. For any one student in a specific classroom (i)

(2) $A_{3j} = t_i + aF_j + bA_{2j} + u_j$

(3) $A_{3j} = c + aF_j + bA_{2j} + u_j$

where c is a constant for students in all classrooms. The results of the six F tests for equality of coefficients showed the hypothesis of no teacher differences could be rejected at the .01 level for whites. For Mexican-Americans, it was not possible to reject the hypothesis at the .10 level.

for students who had been matched up to their respective teachers. Unfortunately, in the two-year sample, Murnane did not investigate lagged teacher characteristics. That is, second grade instructors' characteristics were not included in the estimating equations for third grade achievement. In equation form:

(1-6) $A_{j3} = a_0 + A_{j2} + a_2F + a_3Y + a_4T_3 + u$

and

(1-7) $A_{j2} = a_0 + A_{j1} + a_2F + a_3Y + a_4T_2 + u$

where: A_{j3}, A_{j2}, A_{j1} = achievement of the jth student third, second or first grade[19]

F = dummy variable for male student

Y = vector of background variables including dummy variable for living in subsidized housing, percentage of rental units on the block where the student lived with rents less than $60 per month, and percentage of the population under 18 years of age who lived in a female-headed household

T_3, T_2 = vector of characteristics including experience, possession of a Master's degree, undergraduate major, undergraduate grade-point average, race, sex, and marital status of the third and second grade teacher.

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[19] A_{j1} is not really the student's first grade achievement score but represents the test score at the beginning of the second grade. A_{j2} represents the test at the end of the second grade.

It was therefore impossible to determine if second grade teaching resources had any impact on third grade performance beyond possible indirect effects captured in the lagged achievement variable.

Murnane's results are interesting on several grounds. His treatment of the experience variable was novel in that it highlighted the initial years of experience. Experience was included in the model as a three-piece linear function, constrained to have corner points at two and five years of experience. This specification showed achievement improved dramatically when the instructor was between his or her first and third years of teaching. Students who had an instructor with two years of experience scored on average five points higher than students who had teachers with no experience. Since in grade equivalent score units[20] five points represented five months of progress, this was a substantial difference. The pattern of coefficients from three to five years of experience suggested these teachers were not more effective than instructors with two years of experience. While performance declined in all the samples, the decline was significant in the first cohort only. No consistent relationship was found between performance and teachers with greater than five years of experience. Instructors with five

[20] Achievement scores are reported in a variety of ways: raw scores, standard scores, percentile ranks, stanines, and grade equivalents. A grade equivalent score scale can be thought of as a development scale. It is used to relate raw scores from the various levels to each other. The unit of measurement is one-tenth of the difference between medians for successive grade. Thus, a score of 37 implies the student's raw score on the test is the same as that made by the median pupil in the third grade at the end of the seventh month in that grade (Lindquist and Hieronymus, 1964).

years of experience were as effective as those with ten years of experience. The returns from "learning by doing" were totally exhausted in the first five years.

The only other teacher characteristic consistently related to pupil performance was sex. Male teachers were more effective in teaching both reading and mathematics. No consistent significant relationship was found between performance and race of teacher, highest degree attained, undergraduate majo., undergraduate grade-point average, or marital status. Murnane also investigated whether certain teacher characteristics were more effective with certain types of students. Five interaction variables were tested, but none were significant across the samples.[21]

In contrast to all other researchers, Murnane had explicit peer group measures. In order to substantiate EEO's strong finding on peer group influences, he included the class mean achievement scores and the standard deviation of these scores in his estimating equations. An aggregate measure of student turnover was calculated by subtracting the average class size from the total number of student names in each

[21] The following hypotheses were tested:

1. Male teachers are more effective with male students than with female students.
2. Black teachers are more effective with male students than with female students (or vice versa).
3. The relationship between experience and student performance is different for black, as opposed to white, teachers.
4. Male and/or female teachers have greater success with low achieving students than high achieving students (or vice versa).
5. Black and/or white teachers have greater success with low achieving students than high achieving students (or vice versa).

attendance register. Mean and standard deviation of achievement were unrelated to student performance. Murnane cautioned that the lack of significance was misleading; both measures were biased to the extent that students were non-randomly absent on the days the tests were administered. Student turnover had a consistantly negative effect on reading achievement; the deleterious effect was even greater for students with high initial achievement levels.

Longitudinal data on approximately 800 black and white California students were utilized by Winkler (1977) in an educational production study emphasizing peer group influences. In predicting eighth grade achievement, Winkler used the following explanatory variables: first grade achievement, measures of family background, and peer group composition and teacher characteristics aggregated over the eight years. The advantages of observing students over eight years were greatly offset by the aggregation of the peer and teacher variables. Students were not matched to their respective instructors; therefore, the resources did not accurately reflect the inputs the pupil received.

The teacher variables were calculated by computing the average characteristics of teachers in each grade of each school for specific school years. For example, a student in grade eight in 1964 was assigned the characteristics of 1958 grade one teachers, 1958 grade two teachers, 1958 grade three teachers, 1961 grade four teachers, 1961 grade five teachers, 1961 grade six teachers, 1961 grade seven teachers and 1961 grade eight teachers. Had the student not repeated a grade, he or she would have been in the first grade in 1957, second in 1958, third in 1959, fourth in 1960, fifth in 1961, sixth in 1962, seventh in 1963, and eighth in 1964. The assumption was thus made that the characteristics of teachers in adjacent years (e.g., 1957, 1959) were identical to the characteristics of teachers for which data were recorded (e.g., 1958). To the extent that each pupil's actual teacher characteristics differed from the average characteristics, errors in measurement were introduced resulting in biased coefficients. The calculation of the peer group variables was also complex and will not be explicitly discussed here. It seems sufficient to state that the peer group measures were not classmate characteristics but rather highly aggregated socio-economic indicators based on the number of school-age children in a school attendance area.

Two models were estimated. In the first model, the relevant average characteristics were further aggregated to obtain one variable per characteristic for each student. Thus, a characteristic such as teacher salary was aggregated over the eight years to produce a single salary variable. In the first model for blacks, salary was significant for students in the college preparatory track, but insignificant for students in the vocational track. When salary was replaced by its determinants, experience and level of education, insignificant coefficients resulted. This result was surprising given that salary alone was positive and statistically significant. It is possible that the interaction of experience and credits was the important predictor for blacks. In other words, the relationship may be multiplicative, not additive. The coefficients on quality of undergraduate education were large and significantly positive. No measures of baccalaureate institution quality were available for elementary teachers, however. Teacher salary and experience were important for white students in both tracks; however, teacher credits and undergraduate institution quality were insignificant.

In the second model, Winkler attempted to more fully utilize the longitudinal nature of his data. He could not include all eight years of teacher data, since the construction of the variables implied a high degree of collinearity.[22] Instead, he constrained the coefficients to a particular pattern using the linear parameterization of distributed lags suggested by Almon (1965). Teacher's salary in the current year was a significant predictor for blacks, yet none of the other distributed lag coefficients on salary or experience were significant. A radically different pattern was observed for whites; all eight distributed lag coefficients on salary and experience were significant at the .10 level. The lowest marginal products were observed on the most distant resources. Winkler's results for whites thus implied that previous teachers can have a delayed effect on student achievement.

The final longitudinal study that will be considered in this review was undertaken by Summers and Wolfe (1977). Elementary, junior

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[22]All students in a particular grade, school, and year received identical teacher characteristics. In addition, students in the years for which data were not collected (1957 or 1959) received characteristics from the other years (1958). Thus, third grade students in 1957, 1958, and 1959 from the same school received identical inputs.

and senior high school students were matched to their respective instructor resulting in 627 sixth grade students, 553 eighth grade students, and 716 twelfth grade students. Due to the many problems associated with predicting junior and senior high school achievement, the focus here will be restricted to the elementary sample.

The dependent variable utilized was the change in student composite achievement score on the Iowa Test of Basic Skills from the third to the sixth grade. The school inputs considered were variables from the sixth grade only. The change in achievement from grade three to grade six was thus attributed entirely to the sixth grade instructor. By interacting student and teacher characteristics, Summers and Wolfe demonstrated sixth grade teacher experience was important for high achieving students, but negatively affected the learning growth of low achievers. The ratings[23] of the sixth grade teacher's undergraduate institution, while significant for all types of students, were particularly important for low income pupils. Educational credentials beyond a baccalaureate degree were not discriminating predictors of achievement growth. The instructor's score on the National Teachers' Examination was likewise insignificant.

As substitutes for the unavailable classmate characteristics,

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[23]The Gourman rating of undergraduate programs (Gourman, 1967) was used. The ratings are based on five areas:
1. individual departments
2. administration
3. faculty (including student/staff ratios and research)
4. student services, and
5. general areas such as facilities or alumni support.
The rating is an average of the five areas.

Summers and Wolfe used variables entitled %High Achievers and %Low Achievers. The variables were calculated by using the average percentage of students in the fifth and sixth grades who scored either above the 84th National Percentile or below the 16th National Percentile on the Iowa Test of Basic Skills. Students who tested below grade level were greatly aided by being in a school with high achievers. This finding was particularly significant since it was revealed high achieving students were not adversely affected.

Cross-Sectional, Longitudinal Findings, and Their Deficiencies

In attempting to integrate the findings of the cross-sectional and longitudinal studies, a brief summary of the conclusions regarding teacher characteristics seems warranted. Conclusions regarding teacher's verbal ability, undergraduate training institution, salary, experience, and level of education are discussed below. The findings concerning per pupil expenditures are also discussed due to their close relationship to teacher's salary.

Teacher verbal ability was found to be positive and significant in studies by Bowles and Levin (1968a), Hanushek (1968, 1970), Bowles (1970), Michelson (1970), Guthrie et al. (1971), and Boardman et al. (1973). Coleman et al. (1966) found teacher's verbal ability score to be positive, although its impact was small relative to peer and family background variables. Levin (1970) and Smith (1972) found teacher's verbal ability to be positive, but statistically insignificant, as did Armor (1972) in his northern white and southern black and white equations.

The sole negative finding can be attributed to Armor, who found an inverse relationship between northern black achievement and teacher's verbal ability.

<u>The "quality" of the teacher's undergraduate training</u> was positive and significant in studies by Winkler (1977) and Summers and Wolfe (1977). Levin (1970) found the institution of undergraduate training to be insignificantly related to student achievement.

<u>Teacher salaries</u> were found to have a positive, significant relationship with achievement in studies by Bowles and Levin (1968a), Cohn (1968), Raymond (1968), Averch and Kiesling (1970), Armor (1972), and Winkler (1977). Burkhead, Fox, and Holland (1967) reported a positive sign on salaries in their Atlanta sample. In contrast, Benson et. al. (1965) found a negative sign on salaries in their study involving large urban districts. Two studies, Thomas (1962) and Burkhead, Fox, and Holland (1967) with their Talent sample, concluded starting teacher salaries were significant predictors of student achievement.

<u>Per pupil expenditures</u> were positive and significant in studies by Mollenkopf and Melville (1956), Goodman (1959), and Kiesling (1967) with his subsample of large districts. Coleman et al. (1966) found per pupil expenditures to be insignificant while a negative relationship was reported in the urban district analysis of Kiesling (1969).

<u>Teacher experience</u> was found to have a positive and significant relationship with student achievement in reserach by Goodman (1959), Thomas (1962), Burkhead, Fox, and Holland with their Talent sample, Levin (1970), Michelson (1970) with his white sample, Hanushek (1968,

1970), Guthrie et al. (1971), Murnane (1975), Winkler (1977) with his white sample, and Summers and Wolfe (1977) with their sample of high achievers. Hanushek (1972) and Smith (1972) found teacher's experience to be positive but insignificant. Negative relationships were reported by Burkhead, Fox, and Holland (1967) with their Chicago sample, Katzman (1968), and Summers and Wolfe (1977) with their sample of low achievers.

Teacher's degree level was the most consistent characteristic across the studies. Possession of a Master's or higher degree was insignificantly related to student achievement in studies by Cohn (1968), Katzman (1968), Hanushek (1968, 1970, 1972), Bowles (1969), Levin (1970), Smith (1972), Murnane (1975), Winkler (1977), and Summers and Wolfe (1977).

Ten studies thus showed salary or expenditure levels to be positively related to student achievement. The two exceptions, Benson et al. (1965) and Kiesling (1969), utilized data from large urban centers. Hidden in the aggregation of district figures were high concentrations of low socio-economic and black students. While the latter two studies imply resource expenditures do not have a strong positive impact on urban minorities, the aggregation of school and family resource variables was so pervasive it was unclear which students were responding to the various resources. Expenditure levels may also reflect differential living costs; it is not clear if the figures were representative of relative costs or real purchasing power (Spady, 1973: 149). At least one study has shown that the highest proportion of high salaried teachers are employed in the inner city (Anderson and Mark, 1976). Metropolitan areas may thus have high concentrations of teachers with many years of experience and/or graduate degrees. Despite these difficulties, it seems fairly safe to conclude that higher teacher salaries, which imply higher formal credentials, are positively related to achievement.

If salary levels and formal credentials are proxies for each other, why are the findings on formal credentials so mixed? Aside from purely statistical considerations, the answer may lie partly in the fact that the conclusions regarding experience and degrees are subject to more than one interpretation. For instance, the positive impact of teacher experience is assumed to result from the acquisition of skills over the course of many school years. It is also possible that as teachers accumulate seniority, they transfer to schools in "good" neighborhoods with high achieving students. The association between achievement and experience may thus be a partial reflection of staff selection bias (Spady, 1973:151). Capable, experienced teachers may also have the option of leaving the classroom for higher paying administrative and guidance posts. A selection mechanism of this type will bias downward the experience performance relationship. On the other hand, those individuals who have difficulty coping with students may leave the profession early. Finally, if the pool of new teachers is changing over time,[24] a cross-sectional study many not discover a

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[24]One could argue that each successive pool of new teachers has more sophisticated training. Weaver (1978), however, shows that ability of new teachers (as measured by SAT scores) is decreasing, suggesting perhaps that less capable individuals are entering the profession.

statistical relationship even if one actually exists.

The review of the cross-sectional and longitudinal literature reveals some potential flaws with the methodology employed to determine if characteristics of teachers are instrumental in producing student achievement. Those properties which are desirable but absent from either all or a majority of the studies are enumerated below:

1. A model which attempts to determine the importance of teaching characteristics in the production of student achievement should include measures of both present and past teaching resources. The findings of Coleman et al. (1966), Raymond (1968), Hanushek (1972), and Winkler (1977) suggest previous teacher characteristics have a direct effect on current student achievement. In addition to the direct effects, previous teacher characteristics may be reflected indirectly through the lagged achievement level. The omission of previous teacher characteristics may underestimate the total contribution of instruction and circumscribe the policy implications of the model.

2. Individual student and teacher observations are desirable in order to avoid obscuring the student-teacher relationship by aggregation of variables.

3. The school resources included in the model should reflect only those resources the student actually received. For example, the presence of a science laboratory should not be included as an explanatory variable for business students.

4. Elementary school samples should be utilized whenever possible. Multiple instructors contaminates samples of junior and senior

high school students.

5. Peer influences should be as specific as possible. Ideally we would like a measure of the student's classmates' characteristics.

6. The assumptions of the linear additive specification can be made less restrictive by incorporating squared and interaction terms in the model.

The present study will go beyond the existing literature by incorporating all six of the above desirable properties into its methodology.

Chapter 2

A LONGITUDINAL MODEL OF EDUCATIONAL PRODUCTION

The objective of this chapter is to highlight some basic theoretical aspects of educational production functions and to develop the model to be estimated. The multiple output nature of the educational process and the key inputs - family background, ability, school, and peer group resources - will be discussed. The differing assumptions that underlie educational production as opposed to industrial production are also developed. Finally, since the primary focus of this research is the effect of teaching characteristics over time, a conceptual model outlining the possible direct and indirect impacts of these characteristics on the production of student achievement will be elucidated.

The Output of Education

Educational production is a multiple output process. The outputs can loosely be categorized as cognitive or non-cognitive (Bloom, 1956). Cognitive outputs include general as well as subject-specific increases in ability or knowledge, and are usually measured by achievement test scores. Behavioral attributes such as the extent of one's socialization, or changes in attitudes and preferences, are classified as non-cognitive outputs. In comparison to cognitive outputs, non-cognitive outputs are difficult to identify and measure. As a result, a majority of the empirical studies have concentrated solely on the production of achievement as measured in standardized test scores.

The omission of non-cognitive outputs implies certain subtle assumptions about the "public goods"[1] nature of the inputs; it also has important econometric implications. These assumptions and implications can be clarified by constructing a simple two-equation system for the production of cognitive and non-cognitive outputs.

Let

y_1 = cognitive output (achievement)

y_2 = non-cognitive output (socialization)

x_1 = vector of inputs in the production of y_1

x_2 = vector of inputs in the production of y_2

β_1 = coefficients of x_1

β_2 = coefficients of x_2

ε_1, ε_2 = error terms, assumed uncorrelated with x_1, x_2

(2-1) $y_1 = x_1\beta_1 + \varepsilon_1$

(2-2) $y_2 = x_2\beta_2 + \varepsilon_2$

If the inputs in the production of y_1 are identical to the inputs utilized in the production of y_2, or $x_1 = x_2$, separate least squares

[1]Public goods, as defined in the welfare economics literature, have the property of being "...used simultaneously by all consumers without individual exclusion" (Malinvaud, 1972:201). In certain instances, one individual's consumption or abstention of the good will not cause the slightest change in the resources available to other individuals. In this context we are suggesting that a "public" input in production would be one in which its use in one production process would not cause the "slightest change" in the amount available for another production process.

estimation of the two equations will produce consistent and efficient[2] estimates, regardless of the degree of correlation between ϵ_1 and ϵ_2. If x_1 is a subset of x_2 (or vice versa), the estimates remain consistent but are efficient only if the error terms, ϵ_1 and ϵ_2, are uncorrelated. It is likely that the error terms are correlated. This correlation implies the significance levels of the coefficients will be reduced; however, the estimates will remain unbiased.

Underlying the above formulation is the assumption that y_1 and y_2 can be produced simultaneously with a given set of inputs; inputs employed in the production of y_1 are not "used up," leaving a smaller amount available for the production of y_2. For example, the way in which social studies is taught, while influencing achievement, could also produce a respect for certain value systems and a socialization into the American culture. Presumably, an input like teachers' experience would be equally effective at producing both outputs. On the other hand, if employing an input in the production of achievement

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[2]An estimator is consistent if for sample size T and arbitrarily small ϵ,

$$\lim_{T\to\infty} \text{Prob}(|\hat{\beta} - \beta| < \epsilon) = 1 \quad \text{or} \quad \text{plim}\,\hat{\beta} = \beta .$$

As the sample size becomes infinitely large, the probability distribution converges on the true parameter values. An estimator is efficient if it has the minimum variance among all consistent estimators in its class. In formal terms, $\hat{\beta}$ is an efficient (or best unbiased) estimator of β if $\hat{\beta}$ is unbiased and

$$E(\hat{\beta} - \beta)^2 \leq E(\tilde{\beta} - \beta)^2$$

where $\tilde{\beta}$ is any other unbiased estimator of β (Goldberger, 1964:126-128). For more information on the estimation of equations similar to (2-1) and (2-2), see Zellner (1962:348-368).

diminishes the amount available for production of socialization, a different formulation is suggested. In considering the type of input that would be "used up" in the production of achievement it is clear that inputs such as teacher's experience and level of education would not be reduced. Time, an input heretofore unmentioned, would be consumed in the production process. If we incorporate time in the model we have the following formulation:

(2-3) $y_1 = \beta_1 x_1 + \gamma_1 w + \varepsilon_1$

(2-4) $y_2 = \beta_2 x_2 + \gamma_2(1-w) + \varepsilon_2$

where: w = fraction of the school day spent on the production of y_1 and $(1-w)$ the fraction spent on y_2.[3]

If w is omitted from the specification but uncorrelated with x_1 the estimates remain consistent. If w is positively correlated with x_1 the estimated coefficient for β_1 will be biased upward while the coefficient for β_2 will be biased downward. The biases are reversed if w is negatively correlated with x_1. The magnitude of the biases will depend on the degree of correlation between w and x_1. Since there is no a priori reason to suspect the fraction of time devoted to y_1 or y_2 is correlated with inputs such as teacher's experience or level of education, the problem of biased estimates is unlikely to be severe.

The focus on standardized achievement can be justified on grounds other than it is a relatively precisely measured output. The general

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[3]A more realistic specification would perhaps be one in which w and $(1-w)$ entered equations (2-3) and (2-4) in multiplicative fashion. The results for this case are identical to those given here if (2-3) and (2-4) are interpreted as log-linear relations.

public's concern over cognitive output has been reflected in state legislation requiring students to be proficient in basic skills such as reading and mathematics. Over half the states have in some way mandated achievement as a primary educational objective. An investigation of the inputs involved in the production of achievement is warranted simply because achievement is a highly valued output.

Inputs to Educational Achievement

The inputs employed in the production of achievement may be broadly classified into three categories: (1) family and individual student resources, (2) school resources, and (3) peer group characteristics. Some inputs are truly technological in the sense the can be varied by the educational producer. In contrast, inputs such as father's occupation and race or sex of the student are not alterable by schools and may be considered fixed. The inclusion of these fixed inputs permits the researcher to examine interactions between school resources and the student's background. Under each of the three broad categories, many specific inputs can be identified. The following list is by no means exhaustive, yet it covers many of the more commonly utilized inputs.

Family Background and Student Characteristics

The previous chapter illustrated the importance of family background and individual student characteristics in the production of achievement. This result is not surprising when one considers all of the student's pre-school years, plus half of his waking time when attending school, are spent in the home. Aside from supplying the purely physical environment of food, clothing, and shelter, the family helps shape the pupil's ability and attitudes and contributes directly to pupil performance in the form of time inputs. The pupil also contributes directly in the form of time allocated between attendance and homework. Unfortunately no direct measures of the parent and student inputs exist. Proxies such as socio-economic status, parents' education, race and IQ have been utilized.

IQ is considered a proxy input since it is a doubtful measure of true innate ability. Theoretically, we would like a measure of innate ability which reflects the genetic endowment of the individual. Conceptually, ability should reflect "potential" and achievement should measure "attainment." IQ tests may not adequately measure potential since the scores may reflect genetic and environmental interactions. As an added complication, IQ is known to be highly correlated to socio-economic status. If other background inputs are inadequately measured, IQ may be proxying for the absent family inputs. The coefficient on IQ may thus reflect genetics, genetic and environmental interactions, and family background inputs.

<u>School Resources</u>

The logical focus of most policy discussions regarding achievement is on the school resource vector. School resources allow the greatest possible scope for the application of alternative policies. School input variables include facility characteristics, administrative characteristics, and current and past teaching characteristics. Teaching performance can be decomposed into many parts such as level, recency, and quality of education, years of experience, verbal ability, receptiveness to students, knowledge of subject, time devoted to lecturing and preparation, and forms of classroom presentation. The teaching variables are of particular importance due to the concentration of the instructor's time input and degree of potential interaction with the student.

Peer Group Resources

The performance of an individual student may depend upon the collective performance or expected achievement of the entire class. Students within a class may influence one another and/or the instructor's behavior may be a function of the class characteristics. Peer group variables are thus captured in aggregate characteristics, like class socio-economic status, size, attendance, mean and standard deviation of achievement, and mean and standard deviation of IQ (Hanushek, 1972:25-32). It must be noted, however, that the self-selection of students into schools with particular attributes confounds the interpretation of some of the peer variables. If background factors are not adequately specified in the model, variables such as class mean achievement may simply reflect the socio-economic status and achievement orientation of the individual students.

Educational Production Functions: Assumptions and Caveats

Following Hanushek (1972), the production function for educational achievement in a partiuclar grade or time period can be expressed as follows:

(2-5) $A_{it} = f(A_{it-1}, B_{it}, P_{it}, I_i, S_{it})$

where: A_{it} = vector of educational achievement level of the ith student at time t

A_{it-1} = vector of entering achievement level (achievement at the close of the previous time period)

B_{it} = vector of family influences at time t

P_{it} = vector of peer influences at time t

I_i = innate ability of the ith student

S_{it} = vector of school influences at time t

t = grade or time period.

The quantity of achievement at time t, A_{it}, is thus stated as a function of the entering achievement level, A_{it-1}, and of the family, peer, and school influences over the period being considered. The production function is defined only for non-negative quantities of the outputs and inputs. Negative values of either achievement, family, peer, or school inputs would be meaningless in the present context. The continuous nature of equation (2-5) implies the combinations of family, peer, and school inputs which can be utilized to produce a given level of output are very large. The producer's technology summarizes all the technical information about the input combinations necessary to produce achievement. The production function, by presupposing technical efficiency, demonstrates the maximum output attainable from every possible combination of inputs. Selection of the most economically efficient input combination, given a particular output level, depends upon the prices of the inputs involved (Henderson and Quandt, 1971:54-55).

Applying the framework of industry production to education is not straightforward. It is assumed in most production function estimates outside of education that the profit motive leads to output maximization. It is not clear that incentives exist for educational producers to maximize output. The observations of the educational system thus may not fall on the production frontier. In addition, decision makers in education may not be aware of the technological relationships necessary for this maximization. Many options are available at the organizational and process level. The effects of altering such things as the class organizational structure, curriculum, or length of the school day may not be accurately perceived. Many additional educational decisions are made by the specific instructor and, as a result, are difficult to observe and quantify. If one allows for "skill" differences it becomes even more difficult to define maximum output since the inputs are no longer homogeneous.

The fact that decision makers may not be selecting the output maximizing set of inputs does not necessarily imply that they are not operating on some portion of the production frontier. Skill differences also do not negate the usefulness of the production function framework. Most hiring and salary decisions are based on a set of measurable teacher characteristics, such as years of experience and level of education. The estimated effect of these measured characteristics thus captures the ability to predict or develop more skilled instructors. Even if one rejects the notion that schools always select the best process given the inputs, estimates of the production function can be made conditional upon the existing organizational and process characteristics. All the students analyzed in this study attend elementary public schools in a large metropolitan city. Given that the data are homogenous, the organizational characteristics are likely to be similar across students. When examining the impact of a specific characteristic, such as teacher experience, the coefficient will thus include the direct effect of experience on the output and the indirect effect given the organizational process (Hanushek, 1979:367-371).

A Theoretical Model

As was discussed in Chapter 1, a model which attempts to determine the importance of teaching characteristics in the production of student achievement should include measures of both present and past teaching resources. The omission of prior school resource inputs presumes either that past exposure to school resources will be reflected in earlier achievements or that there is a rapid decay of benefits from previous school resources. In order to deal with these issues, equation (2-5) must be extended to capture possible direct effects from previous characteristics and indirect effects through the lagged achievement level. The estimated marginal products of the various resources will be biased if either of these effects exist and are ignored. The subsequent discussion will be limited to a three-period model; a later section will generalize the results to five periods.

To illustrate the influence of lagged resource inputs, consider the following set of educational production functions in three consecutive periods.

$$(2\text{-}6) \quad A_{i1} = f(B_{i1}, P_{i1}, I_i, S_{i1})$$

$$(2\text{-}7) \quad A_{i2} = f(A_{i1}, B_{i2}, B_{i1}, P_{i2}, P_{i1}, I_i, S_{i2}, S_{i1})$$

$$(2\text{-}8) \quad A_{i3} = f(A_{i2}, B_{i3}, B_{i2}, B_{i1}, P_{i3}, P_{i2}, P_{i1}, I_i, S_{i3}, S_{i2}, S_{i1})$$

where the second subscript refers to the period, and A_i, B_i, P_i, and S_i are defined as in equation (2-5). The assumed recursive structure implies that even if B_{i3}, B_{i2}, P_{i3}, P_{i2}, S_{i3} and S_{i2} are equal to zero, A_{i3} is not necessarily equal to zero.[4]

$$(2\text{-}9) \quad A_{i3} = f(A_{i2}, 0, 0, B_{i1}, 0, 0, P_{i1}, I_i, 0, 0, S_{i1}) \ .$$

The quantity of achievement retained in A_{i3}, given that A_{i2} is fixed, may change with the quantities of inputs employed in the first period. Specific inputs are thus permitted to have an impact beyond the period of their utilization. A detailed discussion of the model, with emphasis on teaching characteristics, may help clarify this point.

The process is visualized in the following manner: the characteristics of the current teacher may influence a student's present level of achievement, but previous teacher characteristics may also have a direct impact. The previous teacher(s) are in part responsible for the "mental set" the student brings to his current situation. For example, an attitude or approach to problem solving may be instilled whose direct influence extends well beyond a single year. In addition, the impact

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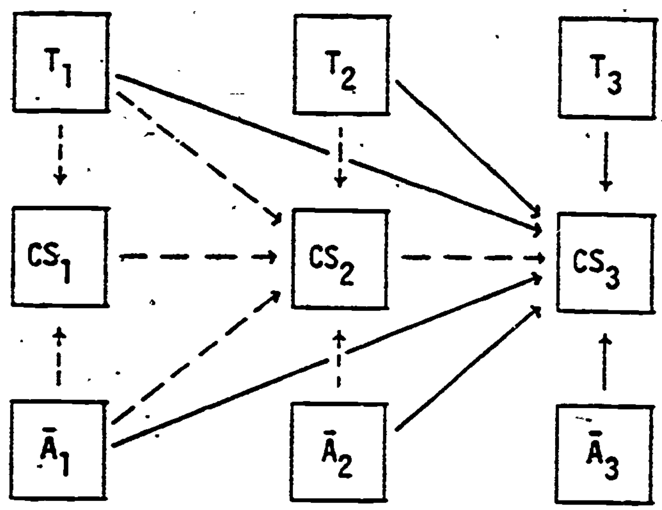
[4]Equation (2-9) would equal zero if the Cobb-Douglas, or double-log, functional form was utilized.

of past teacher characteristics could be embedded in the level of previous achievement. The following simple diagram helps illustrate for one student at grade three the flows of the process.



where: T = teacher characteristics such as experience and level of education

CS = composite score on achievement test

$\bar{A}$ = classmate characteristics such as mean and standard deviation of class achievement

1, 2, 3 = periods.

The model illustrates composite achievement in period three, CS_3, as a function of teacher and classmate characteristics in each period. Two separate effects can be identified: (1) the direct effects of the characteristics on CS_3, shown by the solid line, and (2) the indirect effects on the characteristics, shown by the dashed lines, through the previous score.[5]

The incorporation of the other important inputs, family background, ability and interactions between ability and the teaching characteristics, can be most easily seen by stating the model in equation form. Let

i = periods, 1, 2, and 3

F = family background

A = ability

AT_i = interaction of ability with teaching characteristics

T_i = teaching characteristics

$\bar{A}_i$ = classmate characteristics

CS_i = composite achievement score

γ = coefficient on previous test score, CS_2 and CS_1

$\beta_0, \beta_2, \beta_3$ = coefficients on T_i

$\beta_1, \beta_4, \beta_5$ = coefficients on AT_i

α_1 = coefficients on A

ε_1 = coefficients on F

$\partial_1, \partial_2, \partial_3$ = coefficients on $\bar{A}_i$

μ_i = error terms, assumed uncorrelated across individuals and years.

The three-period model can thus be expressed by the following equations:

---

[5]Although the model will be estimated using linear regression, the diagram and the terminology of direct and indirect effects is similar to that of path analysis. General descriptions of path analysis can be found in Duncan (1966), Heise (1969), Kerlinger and Pedhazur (1973), and Pedhazur (1975).

$$(2\text{-}10)\quad CS_1 = (\beta_0 + \beta_1 A)T_1 + \varepsilon_1 F + \partial_1 \bar{A}_1 + \alpha_1 A + \mu_1$$

$$(2\text{-}11)\quad CS_2 = \gamma CS_1 + (\beta_0 + \beta_1 A)T_2 + \beta_2 T_1 + \beta_4 AT_1 + \varepsilon_1 F + \partial_1 \bar{A}_2 + \partial_2 \bar{A}_1 + \alpha_1 A + \mu_2$$

$$(2\text{-}12)\quad CS_3 = \gamma CS_2 + (\beta_0 + \beta_1 A)T_3 + \beta_2 T_2 + \beta_3 T_1 + \beta_4 AT_2 + \beta_5 AT_1 + \varepsilon_1 F + \partial_1 \bar{A}_3 + \partial_2 \bar{A}_2 + \partial_3 \bar{A}_1 + \alpha_1 A + \mu_3 .$$

The reduced form for achievement in the third period, CS_3, is given by:

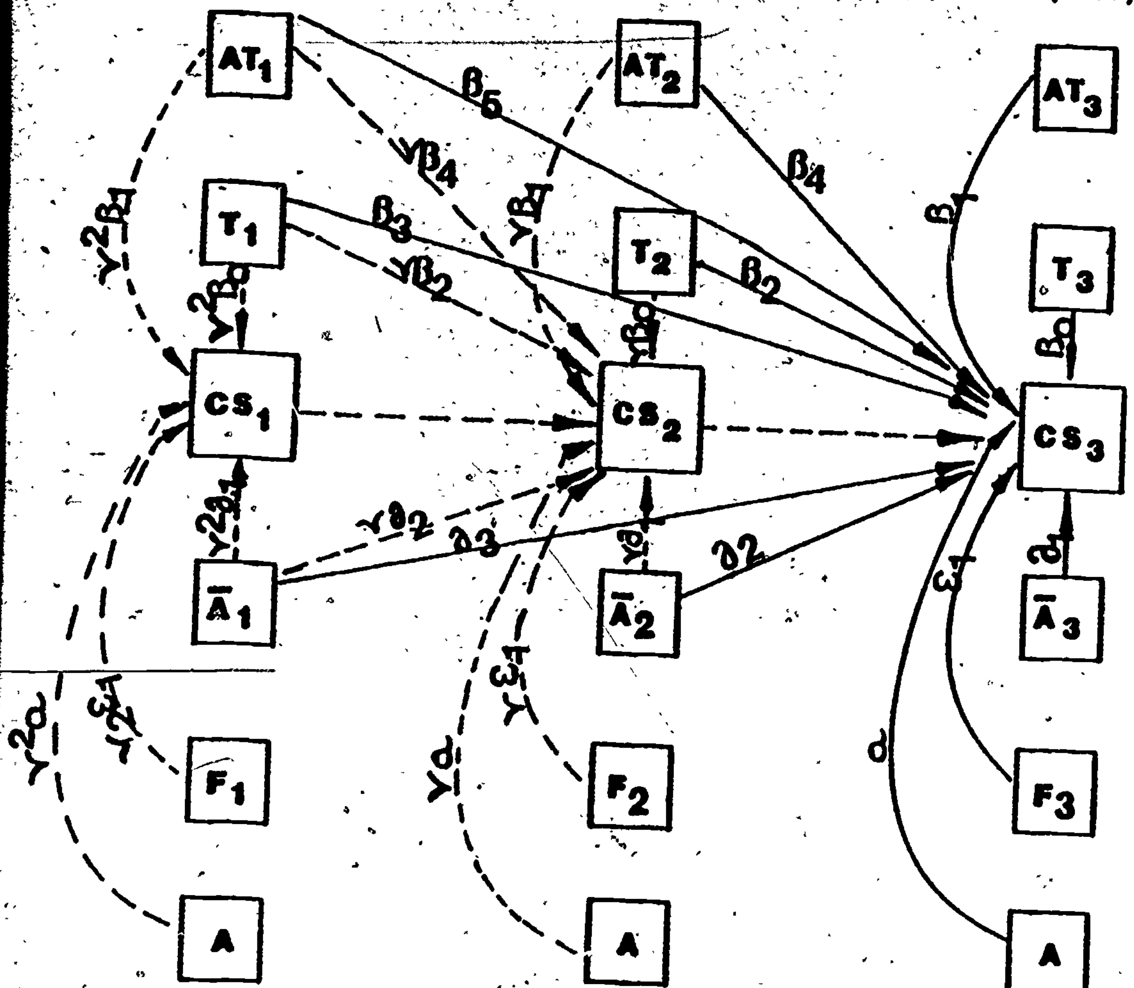
$$(2\text{-}13)\quad CS_3 = (\gamma^2\beta_0 + \gamma\beta_2 + \beta_3)T_1 + (\gamma\beta_0 + \beta_2)T_2 + \beta_0 T_3 + (\gamma^2\beta_1 + \gamma\beta_4 + \beta_5)AT_1 + (\gamma\beta_1 + \beta_4)AT_2 + \beta_1 AT_3 + (\gamma^2\varepsilon + \gamma\varepsilon + \varepsilon)F + (\gamma^2\alpha + \gamma\alpha + \alpha)A + (\gamma^2\partial_1 + \gamma\partial_2 + \partial_3)\bar{A}_1 + (\gamma\partial_1 + \partial_2)\bar{A}_2 + \partial_1\bar{A}_3 + \gamma^2\mu_1 + \gamma\mu_2 + \mu_3 .$$

A flow diagram of equation (2-13) appears in Figure 1. Family background and ability are treated as stock, rather than flow, variables. Since these variables are presumed to be relatively stable over time, the model allows for direct effects within a given time period. Across time periods, however, their influence is only indirectly felt through previous scores. Equation (2-13) thus captures the direct and indirect contributions of the various resources to a given grade.

Gamma (γ), the coefficient on lagged composite score, has been

FIGURE 1

A Diagrammatic Representation of the Reduced Form Equation (2-13)



estimated by a number of researchers, most notably Hanushek (1971), Murnane (1975), and Summers and Wolfe (1977). As Hanushek (1971) argued, a model which included previous achievement in the estimating equations was measuring the "value added" of current school inputs. The true role of gamma, however, has not been fully appreciated. Gamma plays the role of a filter by demonstrating the relative importance of direct versus embedded teaching and classmate characteristics. In the structural equation (equation (2-12)) gamma reflects genetic, environmental, and school effects which are not directly capturable. The reduced form equation (equation (2-13)) separates gamma into indirect components and attributes its magnitude to previous teacher, peer, and school inputs.

By rearranging the terms in equation (2-13), it can be seen the equation is over-identified.

$$
\begin{aligned}
\text{(2-13a)} \quad CS_3 = {} & \beta_0(\gamma^2 T_1 + \gamma T_2 + T_3) + \beta_2(\gamma T_1 + T_2) + \beta_3 T_1 \\
& + \beta_1(\gamma^2 AT_1 + \gamma AT_2 + AT_3) + \beta_4(\gamma AT_1 + AT_2) + \beta_5 AT_1 \\
& + \varepsilon(\gamma^2 F + \gamma F + F) + \alpha(\gamma^2 + \gamma + 1)A \\
& + \partial_1(\gamma^2 \bar{A}_1 + \gamma \bar{A}_2 + \bar{A}_3) + \partial_2(\gamma \bar{A}_1 + \bar{A}_2) + \partial_3 \bar{A}_1 \\
& + \gamma^2 \mu_1 + \gamma \mu_2 + \mu_3 .
\end{aligned}
$$

There are 12 structural parameters and 11 estimated coefficients. To solve the identification problem, the value of gamma will be estimated by an iterative procedure. If the error terms are assumed to be independently normally distributed, the estimates are maximum likelihood.

Equation (2-12) identifies the structural parameters of the model.

$$(2\text{-}12) \quad CS_3 = \gamma CS_2 + (\beta_0 + \beta_1 A)T_3 + \beta_2 T_2 + \beta_3 T_1 + \beta_4 AT_2 + \beta_5 AT_1 + \varepsilon_1 F + \partial_1 \bar{A}_3 + \partial_2 \bar{A}_2 + \partial_3 \bar{A}_1 + \alpha_1 A + \mu_3 .$$

The structural equation provides a direct estimate of gamma. However, this estimate will be biased downward if CS_2 and CS_3 are measured with random error. The estimate will be biased upward if the error components of CS_2 and CS_3 are positively correlated. Thus, both the direct and iterative methods of estimation will be utilized.

The above methodology is flexible enough to account for either exponential growth in achievement or a situation where the amount of achievement retained from previous years diminishes with each successive year. Exponential growth in achievement would be consistent with the idea that each year builds upon and reinforces the preceding year - the material taught in year t-1 is reinforced in year t. In this case, the coefficient on lagged achievement would be greater than one. On the other hand, due to non-applicability and "forgetting," the amount of achievement retained from previous years could diminish. Material taught in year t-1 would be partially, but not completely, carried over to year t. In this case the coefficient on lagged achievement would be less than one. If those teacher characteristics tested are important to either the reinforcement or diminishment explanation, then the interaction of lagged achievement with teacher characteristics will produce significant results.

An Operational Five-Period Model

A description of the data will be reserved until Chapter 3; nonetheless, several modifications of the theoretical model are necessary in order to empirically estimate equations (2-12) and (2-13). The concepts, teacher characteristics, classmate characteristics, family background, and ability, also need to be operationalized. Table (2-1) indicates the variables, or sets of variables, which the data provide for the measurement of the abstract constructs.

Achievement test scores are not usually administered in the first grade. Equation (2-10) is assumed to represent the pupil's first year of schooling. At this point the student has been exposed to one set of classmates and one instructor. The primary inputs are the environmental and genetic influences of the family. Since a student in the particular school system under study is not tested until grade three, he or she will already have been exposed to genetic and environmental influences, including two years of schooling influences, which are not separately measurable. The equations must be modified to include the earliest composite achievement score. The coefficient on the early composite score will thus reflect genetic, environmental, first, and second grade school effects.[6] The existence of lagged direct and indirect effects of previous resources can only be tested beyond the third grade. The modified equations for a five-period model are thus:

[6] Hanushek (1972) provides a complete discussion on the interpretation of the earliest achievement score.

TABLE 2-1

Variables Utilized to Measure Concepts

Teacher Characteristics (T_i)

Measure	Definition
Texp76	Years of experience - 1976 instructor
Texp75	Years of experience - 1975 instructor
Texp74	Years of experience - 1974 instructor
Texp73	Years of experience - 1973 instructor
Hdeg76	Level of education - 1976 instructor, = 1 if M.A., Ed. Spec. or Ph.D.
Hdeg75	Level of education - 1975 instructor
Hdeg74	Level of education - 1974 instructor
Hdeg73	Level of education - 1973 instructor
College Rating76	Gourman undergraduate college rating - 1976 instructor, = 1 ≥ 300
College Rating75	Gourman undergrad. college rating - 1975 instructor
College Rating74	Gourman undergrad. college rating - 1974 instructor
College Rating73	Gourman undergrad. college rating - 1973 instructor
Eddeg76	1976 instructor, = 1 if degree in education
Eddeg75	1975 instructor
Eddeg74	1974 instructor
Eddeg73	1973 instructor
Recency76	Recency of B.A. degree - 1976 instructor
Recency75	Recency of B.A. degree - 1975 instructor
Recency74	Recency of B.A. degree - 1974 instructor
Recency73	Recency of B.A. degree - 1973 instructor

TABLE 2-1 (continued)

Measure	Definition
TAttend76	1976 school - percent teacher attendance
TAttend75	1975 school - percent teacher attendance
TAttend74	1974 school - percent teacher attendance
Tnw76	1976 school - percent non-white teachers
Tnw75	1975 school - percent non-white teachers
TSex76	Sex - 1976 instructor, = 1 if male
TSex75	Sex - 1975 instructor
TSex74	Sex - 1974 instructor
TSex73	Sex - 1973 instructor
	Ability (A)
IQ	Stanford-Binet Intelligence Test Score, grade four
	Teacher/Ability Interactions (AT_i)
IQ * Texp76	as defined above
IQ * Texp75	as defined above
IQ * Texp74	as defined above
IQ * Texp73	as defined above
IQ * Hdeg76	as defined above
IQ * Hdeg75	as defined above
IQ * Hdeg74	as defined above
IQ * Hdeg73	as defined above
IQ * College Rating76	as defined above

TABLE 2-1 (continued)

Measure	Definition
IQ * College Rating75	as defined above
IQ * College Rating74	as defined above
IQ * College Rating73	as defined above
	Family Background (F)
Race	B = Black, W = White
Sex	Student's sex, = 1 if female
Title76	1976 school, = 1 if eligible for a federally funded compensatory program[a]
Title75	1975 school
Title74	1974 school
Title73	1973 school
Title IS76	1976 school, number of students enrolled in compensatory programs
Title IS75	19 school
Title IS74	1974 school
	Classmate or Peer Characteristics ($\bar{A}_i$)
Mean CS76	1976 classroom mean on Iowa Test of Basic Skills (ITBS)
Mean CS75	1975 classroom mean on ITBS
Mean CS74	1974 classroom mean on ITBS
Mean CS73	1973 classroom mean on ITBS

TABLE 2-1 (continued)

Measure	Definition
SDCS76	1976 classroom standard deviation on ITBS
SDCS75	1975 classroom standard deviation on ITBS
SDCS74	1974 classroom standard deviation on ITBS
SDCS73	1973 classroom standard deviation on ITBS
Class Size76	1976 classroom size, = 1 if ≥ 30
Class Size75	1975 classroom size
Class Size74	1974 classroom size
Class Size73	1973 classroom size
Attend76	1976 school - percent student attendance
Attend75	1975 school - percent student attendance
Attend74	1974 school - percent student attendance
School76	School attended in 1976
Schsize76	1976 school - enrollment
Schsize75	1975 school - enrollment
Schsize74	1974 school - enrollment
Ratio76	1976 school - pupil/teacher ratio
Ratio75	1975 school - pupil/teacher ratio
Ratio74	1974 school - pupil/teacher ratio
	Previous and Current Achievement (CS_i)
CS76	Iowa Test of Basic Skills Composite Score - 1976
CS75	Iowa Test of Basic Skills Composite Score - 1975
CS74	Iowa Test of Basic Skills Composite Score - 1974

TABLE 2-1 (continued)

Measure	Definition
CS73	Iowa Test of Basic Skills Composite Score - 1973
CS72	Iowa Test of Basic Skills Composite Score - 1972

[a] A school is eligible for compensatory programs if the number of school-age children in the school attendance area on Aid to Families with Dependent Children (AFDC) divided by the total number of children in the area exceeds the city average.

$$\text{(2-14)} \quad CS_{73} = \gamma CS_{72} + (\beta_0 + \beta_1 A)T_{73} + \partial_1 \bar{A}_{73} + a_1 A + \varepsilon_1 F + \mu_{73}$$

$$\text{(2-15)} \quad CS_{74} = \gamma CS_{73} + (\beta_0 + \beta_1 A)T_{74} + \beta_2 T_{73} + \partial_1 \bar{A}_{74} + \partial_2 \bar{A}_{73} + \beta_5 AT_{73} + a_1 A + \varepsilon_1 F + \mu_{74}$$

$$\text{(2-16)} \quad CS_{75} = \gamma CS_{74} + (\beta_0 + \beta_1 A)T_{75} + \beta_2 T_{74} + \beta_3 T_{73} + \partial_1 \bar{A}_{75} + \partial_2 \bar{A}_{74} + \partial_3 \bar{A}_{73} + \beta_5 AT_{74} + \beta_6 AT_{73} + a_1 A + \varepsilon_1 F + \mu_{75}$$

$$\text{(2-17)} \quad CS_{76} = \gamma CS_{75} + (\beta_0 + \beta_1 A)T_{76} + \beta_2 T_{75} + \beta_3 T_{74} + \beta_4 T_{73} + \partial_1 \bar{A}_{76} + \partial_2 \bar{A}_{75} + \partial_3 \bar{A}_{74} + \partial_4 \bar{A}_{73} + \beta_5 AT_{75} + \beta_6 AT_{74} + \beta_7 AT_{73} + a_1 A + \varepsilon_1 F + \mu_{76} .$$

The reduced form equation for 1976 is given by:

$$\text{(2-18)} \quad CS_{76} = \gamma^4 CS_{72} + (\gamma^3 \beta_0 + \gamma^2 \beta_2 + \gamma\beta_3 + \beta_4)T_{73} + (\gamma^2 \beta_0 + \gamma\beta_2 + \beta_3)T_{74} + (\gamma\beta_0 + \beta_2)T_{75} + \beta_0 T_{76} + (\gamma^3 \partial_1 + \gamma^2 \partial_2 + \gamma\partial_3 + \partial_4)\bar{A}_{73} + (\gamma^2 \partial_1 + \gamma\partial_2 + \partial_3)\bar{A}_{74} + (\gamma\partial_1 + \partial_2)\bar{A}_{75} + \partial_1 \bar{A}_{76} + (\gamma^3 \beta_1 + \gamma^2 \beta_5 + \gamma\beta_6 + \beta_7)AT_{73} + (\gamma^2 \beta_1 + \gamma\beta_5 + \beta_6)AT_{74} + (\gamma\beta_1 + \beta_5)AT_{75} + \beta_1 AT_{76} + (\gamma^3 a + \gamma^2 a + \gamma a + a)A + (\gamma^3 \varepsilon + \gamma^2 \varepsilon + \gamma\varepsilon + \varepsilon)F + \gamma^3 \mu_{73} + \gamma^2 \mu_{74} + \gamma\mu_{75} + \mu_{76} .$$

By rearranging terms:

$$\text{(2-18a)}\quad CS_{76} - \gamma^4 CS_{72} = \beta_0(\gamma^3 T_{73} + \gamma^2 T_{74} + \gamma T_{75} + T_{76})$$
$$+ \beta_2(\gamma^2 T_{73} + \gamma T_{74} + T_{75}) + \beta_3(\gamma T_{73} + T_{74}) + \beta_4 T_{73}$$
$$+ \beta_1(\gamma^3 AT_{73} + \gamma^2 AT_{74} + \gamma AT_{75} + AT_{76})$$
$$+ \beta_5(\gamma^2 AT_{73} + \gamma AT_{74} + AT_{75}) + \beta_6(\gamma AT_{73} + AT_{74}) + \beta_7 AT_{73}$$
$$+ \partial_1(\gamma^3 \bar{A}_{73} + \gamma^2 \bar{A}_{74} + \gamma \bar{A}_{75} + \bar{A}_{76})$$
$$+ \partial_2(\gamma^2 \bar{A}_{73} + \gamma \bar{A}_{74} + \bar{A}_{75}) + \partial_3(\gamma \bar{A}_{73} + \bar{A}_{74}) + \partial_4 \bar{A}_{73}$$
$$+ a(\gamma^3 + \gamma^2 + \gamma + 1)A + \varepsilon(\gamma^3 + \gamma^2 + \gamma + 1)F$$
$$+ \gamma^3 \mu_{73} + \gamma^2 \mu_{74} + \gamma \mu_{75} + \mu_{76} .$$

where the subscripts refer to the year and the variables measuring T_i, AT_i, A, F, $\bar{A}_i$, and CS_i are defined in Table (2-1).

Since the theory provides little guidance on the choice of functional forms, several alternative specifications, including linear-additive, double-log, and log-linear, will be tested. The assumptions underlying the various specifications have important implications for the production function. For example, the linear-additive form implies constant marginal products for each input independent of the level of that input, as well as the levels of all the other inputs. The restrictive nature of this assumption can be seen by considering class size as an input into the production function. The effect of adding one student to a class is independent of the size of the class and also independent of other inputs, such as the quality of the instructor. However, non-linearities can be incorporated into the linear-additive model by utilizing quadratic and multiplicative terms.

The double-log functional form goes to the opposite extreme of the straight linear-additive specification. It assumes a unitary elasticity of substitution between inputs. The double-log specification does, however, allow for an explicit test of whether the marginal product of a current year input depends upon previous years' inputs. In the case of teaching characteristics, it would be particularly illuminating to discover the marginal product of a current year input, like teacher's experience, was dependent upon past teacher's experience.

The log-linear functional form assumes an underlying growth process. A simplified example of such a model would be expressed as follows:

$$(2\text{-}19) \quad A_{i3} = A_{i2}^{\gamma} \, e^{\beta B_{i3} + aP_{i3} + \partial I_i + \varepsilon S_{i3} + \mu}$$

where B_i, P_i, I_i, and S_i are defined as in equation (2-5) and μ is the composite error term. The exponent on e would be interpreted as the percentage growth rate applicable to the previous year's stock of knowledge.

The preceding discussion has illustrated several important aspects of educational production. In addition to consideration of theoretical issues, an operational model, designed specifically to test for direct and indirect effects of current and past resources, was introduced. With the aid of longitudinal data the marginal products of teaching characteristics can now be more accurately determined. The next logical focus of this reserach will thus entail a description of the data and a discussion of the empirical results.

Chapter 3

DESCRIPTION OF THE DATA AND EMPIRICAL RESULTS

At the conclusion of Chapter 1, six properties were stated to be desirable when undertaking research to determine the role of teaching resources in production of student achievement. The preceding chapter dealt with the potential problem of direct and indirect effects of previous teaching characteristics. The present chapter will describe the longitudinal data employed to determine the importance of these effects. In the description it will become clear that the five remaining properties, (1) utilization of data where students are matched to their respective instructors, (2) utilization of data on elementary school students, (3) inclusion of specific peer (classmate) characteristics, (4) specification of interaction variables, and (5) inclusion of variables relevant to each individual student, will also be incorporated in this study. The sample description will be followed by the results of estimating the structural and reduced form equations (equations (2-17) and (2-18)).

Description of the Data

Access to an exceptionally fine data base was made possible by two separate sources. The Board of Education of a large midwestern city supplied student achievement records[1] for 313,456 students spanning the

[1] At this point, one record exists for each year the student completes the achievement test.

years 1968 through 1976 and grades three through eight. The state in which the city is located supplied salary, experience, and degree information on all certified teachers for the identical years. Students were matched to their respective teachers by equating the teacher name, school, and year across the two data files. A longitudinal history for each student was then constructed where each year's achievement record was followed by the characteristics of the instructor for that year. A detailed discussion of the procedures involved in merging the student and teacher data is discussed in Appendix A; only a brief summary will be presented here.

The first three years of student data, 1968 through 1971, were eliminated largely because accurate, systematic data management did not begin until 1971. The original sample of 313,456 student records was reduced in this first step to 234,910 records. The complexity of the study further necessitated elimination of an incomplete sample of private, parochial, junior high or special school students. This second step removed 15,785 records, leaving 219,125.

The existence of duplicate student numbers (the same identifier number inadvertently assigned to two different students) reduced the sample to 215,886 student records. Of these 215,886 student records, 199,583 were successfully matched with the teacher data. The 16,303 student records which could not be matched to teacher data fell into four categories:

1. Non-matching years - the largest category was composed of cases where the instructor in the student achievement file did not

appear in the teacher file until the subsequent year. Since the teacher file was constructed in early September for payroll purposes, these cases largely reflected late hiring of teachers in response to unexpectedly high enrollments. Given that more experienced teachers were already placed in schools throughout the system, the new hires were either inexperienced teachers or experienced teachers who had just entered the city's labor market. Close examination of these cases showed inexperienced teachers were predominant.

2. Teachers of professional leave - the instructor in the student achievement file was coded as being on professional leave of absence in the teacher file. Professional leave was often granted to instructors involved in private or federally funded research projects. These instructors may actually have been in the classroom, yet their salary was covered by sources other than the public school system. Since the length of the instructor's stay in the classroom and the form of their compensation could not be determined, these cases remained without teacher data.

3. Non-valid teacher names - no teacher names were associated with 4,563 student records. Due to possible biases associated with this situation, such as poor teachers deliberately leaving the achievement forms blank, every effort was made to determine the student's instructor. Using school attendance reports, correct identification was made for 2,870 students, leaving approximately 1,600 records, or 10 percent of the total unmerged records, with an invalid or "blank" teacher name.

4. Substitutes - a small number of students had instructors

who never appeared in the teacher file and thus may not have been certified by the state. Additional data supplied by the Board of Education revealed these teachers were substitutes. Although no information was available concerning their characteristics or length of stay in the classroom, one might expect these teachers to be less experienced than their permanently employed counterparts. In terms of degree level, substitutes are not likely to differ from the main teacher population. College degrees are not formally required, yet informal rules dictate their possession. A large excess supply of recently graduated teachers virtually guarantees that substitutes will have baccalaureate degrees.

On the whole, the teachers involved in the unmerged student records probably possessed little classroom experience. This tendency toward exclusion of students with inexperienced teachers will bias the final samples if experience implies something different for omitted, as opposed to included, teachers. The number of excluded cases is only eight percent of the total number of potential records. Inexperienced teachers are still well represented in the final samples, as Tables (B-1), (B-5), and (B-9) in Appendix B illustrate.

School-Level Data

The matching of student records to teacher data was supplemented by data aggregated at the school level. The variables included each school's enrollment, number of Title I students,[2] percentage of student

[2]Title I students are those who are enrolled in federally funded remedial compensatory programs. If a student is (1) in a

attendance, percentage of teacher attendance, percentage of non-white students,[3] percentage of non-white teachers, and the pupil-teacher ratio.

Rating Data

In order to test for a possible relationship between the teacher's undergraduate and/or graduate training and student achievement, two variables were added representing the Gourman (1967) ratings of the instructor's baccalaureate institution and graduate institution.

Peer Data

The comprehensiveness of the data further permitted construction of specific peer group variables. Grouping students by classroom, school, and year, eight variables were created to test for the peer

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Title I school, and (2) had achievement scores which fall below the national average in specified areas according to the following scale:

Grade	1st	2nd	3rd	4th	5th	6th	7th	8th
Number of months below national average on Iowa Test of Basic Skills	2	4	6	8	10	12	14	16

then he or she is eligible for Title I programs. Title I programs include partial day reading laboratories, partial day math laboratories, and the comprehensive all-day programs such as Follow Through and Rooms of Fifteen. A school is eligible to receive Title I funds, and is thus designated a Title I school, if the number of school-age children in the school attendance area receiving Aid to Families with Dependent Children divided by the total number of children in the area is greater than or equal to the city average (currently 45 percent).

[3]Percentage of non-white students is defined as the percentage of non-white pupils as of October 31, 1975. Racial data are collected for each classroom by teacher observation; students are never asked their race or ancestry.

group's impact on student achievement. The variables included:

1. mean achievement of the class on the Iowa Test of Basic Skills
2. standard deviation of classroom achievement
3. variance of classroom achievement
4. skewness of classroom achievement
5. mean IQ of the class on the Stanford-Binet Intelligence test
6. standard deviation of classroom IQ
7. variance of classroom IQ
8. skewness of classroom IQ.

While peer group variables could be constructed for 99 percent of the total number of records, several words of caution are necessary. If a student was absent the day the achievement tests were administered, that student would not appear in the student file for the given year. If low achievers are systematically absent, variables such as class mean achievement will be over-estimates of the true classroom mean. A rough check on the number of absences was made by comparing published classroom attendance counts with the class sizes generated from the student file. In a majority of cases, the student file classroom counts deviated only slightly from the published attendance figures. The possibility of bias appeared to be minimal; nonetheless, the comparison was still rather crude. The published figures reflected March classroom attendance in contrast to the achievement tests which were administered in May.

Racial Data

The chief limitation of the data is lack of adequate measures of family background or socio-economic status. The acquisition of student racial data was particularly important in this context. Since race and socio-economic status are known to be highly correlated, race will serve as a crude proxy for the absent family background inputs. Despite the use of a proxy, the lack of family background variables is not a trivial problem for it confounds the interpretation of other variables. The correlation of family background with innate ability (IQ) and/or teaching characteristics may cause the coefficients on these variables to be overstated if background measures are not adequately measured in the statistical model.

Racial information was available on students who were enrolled in the city school system, elementary or secondary, as of September 1976. It should be kept in mind that the students utilized in this study spanned the years 1971 through 1976. Pupils in the eighth grade in 1971 would not be enrolled in secondary school in 1976, unless they repeated a grade. Racial data could not be found for these records nor could racial data be found for students who transferred to private or parochial schools or whose families moved prior to September 1976.

Once the racial data were matched with the student-teacher file, a longitudinal history for each student was created. The student identification number, race, and sex variables were placed at the front of this new record followed by up to six years of achievement data, teacher data, school level data, college rating data, and peer group data.

Following this construction, 91,595 student records remained to constitute the longitudinal history file. Slightly over half of these records included racial data. The operational model outlined in Chapter 2 requires students to be enrolled in the system consecutive years. The statistical analysis was thus limited to those 6,605 students with racial data who were present in the longitudinal history file at least five consecutive years.[4]

Representativeness of the Sample

Comparison of the racial distribution of the longitudinal history file with the smaller sample (see Table (3-1)) suggested that the five year requirement may have biased the sample by under-representation of black students. The chief reason for the discrepancy centers around the collection of the racial data and the actual racial distribution of the schools in 1972. As was stated previously, racial data were available for students enrolled in the system as of September 1976. A student present five consecutive years would have to be enrolled in a city school in 1972. The racial distribution at that time closely approximated the distribution of the smaller sample. White movement to the suburbs, rather than higher black mobility rates, was probably the chief reason the total sample contained more black students.

[4] In order to meet the five consecutive year constraint, a student would have to have been in the third or fourth grade in either 1971 or 1972. Of the 91,595 unique students, 21,117 or 23 percent, were in the third or fourth grades for the relevant years. Requiring racial data reduced this maximum potential sample to 11,842 students. The 6,605 students with racial data thus represented 31 percent of the total potential sample or 55 percent of the total potential racial sample.

TABLE 3-1

Racial Distribution of the Data vis-à-vis the City Schools

Racial Distribution of Total Longitudinal History File

Race	Frequency	Percent
Black	37,890	75.63
White	12,209	24.37
Missing data	41,496	
Total	91,595	

Racial Distribution of the Five/Six Year Sample

Race	Frequency	Percent
Black	4,471	67.7
White	2,134	32.3
Total	6,605	

Actual Racial Distribution of the City Schools

1971 - 1972

Race	Frequency	Percent
Black	73,221	67.4
White	35,459	32.6
Total	108,680	

1975 - 1976

Race	Frequency	Percent
Black	61,672	70.4
White	25,938	29.6
Total	87,610	

Once the sample was restricted to five year students with racial data, a further decision was made to stratify the sample on the basis of race. This stratification was justified on two grounds: (1) the lack of adequate family background variables such as mother and father's occupation, education, or income, implied race would be serving as a proxy for social class. Sample stratification was permissible, since as Hanushek (1971:283) pointed out, the nominal values of the proxies may not have had the same meaning across groups; and (2) no a priori reason existed to believe the two groups had identical production processes. Conventional tests of sample homogeneity for equation (2-18) confirmed the above suppositions. The null hypothesis of no differences in the two populations was rejected at the .05 level.[5] Subsequent discussion of the empirical results will thus focus on

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[5]Equation (2-18), with the exception of a race dummy variable, was estimated for the entire population. The same model was estimated for the separate black and white populations. Following Chow (1960) and Raines (1974), the F-statistic was calculated by:

$$F_{df_u}^{df_r - df_u} = \frac{SSE_r - SSE_u / df_r - df_u}{SSE_u / df_u}$$

where: SSE_r = sum of squared errors from the restricted regression (entire population)

SSE_u = sum of squared errors from the unrestricted regression (sum of SSE from the separate samples)

df_r = degrees of freedom for the restricted regression

df_u = degrees of freedom for the unrestricted regression.

Pooling was inappropriate since the F-statistic equalled:

$$1.79 > F_{2408,.01}^{489} = 1.15 .$$

separate white and black samples.

Estimation of the Operational Five-Period Model

The remaining pages of this chapter will be divided into four major sections. The first will focus on the results of estimating the structural and reduced form equations (equations (2-17) and (2-18)) for white students. Since the sample of black students was further stratified on the basis of grade,[6] the next two sections will highlight the structural and reduced form results for black seventh and eighth grade students. In all three samples the linear specification of the model with squared and interaction terms proved superior to alternative functional forms tested. The final section will summarize the results across the three samples. Particular emphasis will be placed on the linkage between the conclusions regarding each particular variable and the concept it was designed to measure (see Table (2-1)).

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[6]Requiring students to be present five consecutive years implied two grade patterns. Excluding repeaters, a student in the fourth grade in 1972 would have been an eighth grade student in 1976. Similarly, a third grade student in 1972 would have been a seventh grade student in 1976. Equation (2-18) was estimated for the entire population. The same model was estimated for seventh and eighth grade populations. Tests of sample homogeneity illustrated the null hypothesis of no differences in the two populations could be accepted at the .01 level for white students. The F-statistic equalled:

$$1.27 < F^{100}_{1348,.01} = 1.38 .$$

The null hypothesis was rejected for black students. The F-statistic equalled:

$$1.34 > F^{166}_{1348,.01} = 1.28 .$$

White Students

Five consecutive years of data were associated with each student. The impact of four years of school and peer resources (1973-1976) on student achievement could thus be examined. The earliest composite score, introduced in the reduced form equation to control for environmental, genetic, and school effects which were not capturable, was taken from the 1972 data. A great many teacher, school, peer, and interaction variables were tested and it is not feasible to report each regression. Only selected, pertinent regressions will be discussed in detail. Except for teachers' experience and level of education, only those variables with t-statistics significant at the .05 level appear in the final structural equations.[7] Following various structural equation estimates, the variables which did not appear to significantly effect student achievement will be discussed. The section will conclude with the results of estimating the reduced form equations (equations (2-18) and (2-18a)).

Equations (3-1), (3-2), and Table (B-4) of Appendix B provide estimates of the structural equation. The reduced form equation estimates and variable definitions appear in Tables (3-4), (3-5), and (3-6). Frequencies on teachers' experience and level of education appear in Tables (B-1) and (B-2). Variable definitions, means, and standard

[7] Two exceptions to this rule need to be noted: (1) Current year (1976) variables with insignificant t-statistics were included if the corresponding lagged variable's t-statistic was significant. (2) All variables, regardless of significance, were included in structural equation estimates which utilized 1976 school as a dummy variable.

deviations appear in Table (3-2). A complete list of variable definitions appears in Table (2-1) of Chapter 2.

<u>Structural equation estimates</u>. The estimated structure of equation (2-17) is presented in equation (3-1). When the current (1976) teacher's years of experience[8] and level of education were entered in the equation, along with three previous (1973-1975) teachers' characteristics, some interesting results emerged.

$$\text{(3-1)}\quad CS76 = 1.37 + \underset{(42.29)}{.849CS75} + \underset{(8.33)}{.145IQ} + \underset{(.67)}{.044Texp76} - \underset{(-.10)}{.0001Texp76^2}$$

$$+ \underset{(2.69)}{.136Texp75} - \underset{(-3.18)}{.003Texp75^2} + \underset{(1.56)}{.091Texp74} - \underset{(-1.77)}{.002Texp74^2}$$

$$+ \underset{(.59)}{.028Texp73} - \underset{(-.84)}{.0009Texp73^2} - \underset{(-2.03)}{.715Hdeg76} + \underset{(1.67)}{.660Hdeg75}$$

$$- \underset{(-1.51)}{.577Hdeg74} - \underset{(-1.38)}{.569Hdeg73} - \underset{(-1.12)}{.367ClassSize76}$$

$$- \underset{(-2.18)}{.728ClassSize75} + \underset{(7.37)}{.161MeanCS76} - \underset{(-3.07)}{.404Attend76}$$

$$+ \underset{(2.73)}{.286Attend75} + \underset{(.10)}{.003TN76} + \underset{(2.60)}{.074TNW75}$$

t-statistics appear in parentheses below each coefficient; $R^2 = .903$; n = 1,015.

The coefficients on experience were all of the correct sign

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[8] As was discussed in the previous chapter, non-linearities can be incorporated into the model by utilizing squared and multiplicative terms. A squared experience term has been included in all the reported regressions. Regressions omitting the squared experience terms were inferior to the reported results.

TABLE 3-2

White Sample: Variable Definitions, Means, and Standard Deviations

Variable	Mean	Standard Deviation	Definition
CS76	84.26	15.70	1976 Iowa Test of Basic Skills composite score - seventh or eighth grade
CS75	75.10	14.47	1975 Iowa Test of Basic Skills composite score - sixth or seventh grade
IQ	102.27	13.49	Stanford-Binet Intelligence Test Score
Texp76	16.82	9.78	Years of teaching experience - 1976 instructor
Texp75	16.34	11.27	Years of teaching experience - 1975 instructor
Texp74	15.84	11.36	Years of teaching experience - 1974 instructor
Texp73	14.82	12.27	Years of teaching experience - 1973 instructor
Hdeg76	.3[illegible]1		Level of education - 1976 instructor =1 if Master's, Education Specialist or Ph.D. degree =0 if B.A.
Hdeg75	.381		Level of education - 1975 instructor =1 if Master's, Education Specialist or Ph.D. degree =0 if B.A.
Hdeg74	.329		Level of education - 1974 instructor =1 if Master's, Education Specialist or Ph.D. degree =0 if B.A.

(cont.)

TABLE 3-2 (continued)

Variable	Mean	Standard Deviation	Definition
Hdeg73	.297		Level of education - 1973 instructor =1 if Master's, Education Specialist or Ph.D. degree =0 if B.A.
MeanCS76	81.35	11.91	1976 classroom mean score on the Iowa Test of Basic Skills
Attend76	91.97	2.02	Percentage of student attendance - 1976 school
Attend75	92.36	2.58	Percentage of student attendance - 1975 school
TNW76	15.42	8.78	Percentage of non-white teachers in student's school - 1976
TNW75	11.27	10.03	Percentage of non-white teachers in student's school - 1975
ClassSize76	.501		1976 class size =1 if class size ≥ 30 =0 if class size < 30
ClassSize75	.649		1975 class size =1 if class size ≥ 30 =0 if class size < 30

(positive on the linear term and negative on the squared term indicating diminishing returns); yet, the t-statistics were only significant for the 1975 instructor. By differentiating equation (3-1) with respect to Texp75 and setting the derivative equal to zero, it can be seen that the number of years of experience that maximizes white achievement equals 23. The strength of the 1975 coefficient is surprising since one would have expected the characteristics of the current year's instructor to have had the greatest impact on achievement. Inspection of the stratified grade sample (see note 6) revealed that the t-statistic on 1975 instructor's experience equalled 2.46 for seventh grade students and it was 1.57 for eighth grade students. As was the case with the combined sample, however, the coefficients were small, equalling .250 and .157 for seventh and eighth grades, respectively. Thus, an additional year of experience is estimated to raise achievement levels by at most 0.25 points.

The coefficients on degree level were inconsistent. The effect of the current instructor's level of education was significantly negative. The influence of the 1973 and 1974 instructor's degree level was also negative, but degree of the 1975 instructor had a weak positive effect on composite score. Examination of the stratified grade samples indicated that degree level in this year had a negative, but insignificant, coefficient. It appeared that the slight positive effect was discerned only by the combined sample. It was not possible to examine alternative configurations at degree level. Only a small fraction of teachers possessed degrees beyond the baccalaureate level (see Tables

(4-1) and (B-2)).

Two peer group variables, 1976 classroom mean achievement score and 1975 classroom size, were statistically significant. The coefficient on 1976 classroom mean achievement indicated that a 10 point increase in class mean would raise a student's achievement score 1.6 months. It should be noted, however, that current and past classroom mean scores were highly correlated (see Table (B-3) in Appendix B). If the class size was 30 or more in 1975 or 1976, achievement was negatively affected, although the coefficient was significant only on the 1975 variable.

The significant school level variables included the percentage of student attendance in the 1976 school and the percentage of student attendance in the 1975 school. A positive sign on attendance would imply that the presence of a student's peers contributed to his or her level of achievement. On the other hand, a negative sign could imply an ineffective teacher, regardless of his or her formal credentials, the influence of which is being captured by the attendance variable. The results reported in equation (3-1) do not confirm either interpretation. Since many students were in the same elementary school for at least two years, the school level variables were highly correlated. The presence of multi-collinearity may explain the sign reversals on attendance and preclude any definitive judgment concerning the variable's interpretation. In general, the problem of multi-collinearity is exacerbated by the fact that the independent variables are not correlated with the dependent variable so much as they are correlated with one another. Despite the high correlation between current and lagged school-level variables, it was still interesting to observe that the higher the percentage of non-white teachers in the school (TNW75, TNW76), the higher white achievement. In 1975, roughly 90 percent of the white students in the sample attended schools where less than 20 percent of the instructors were non-white. Of these 90 percent, 21 percent attended a school with no black instructors. Black instructors, teaching in predominantly white schools,[9] may have been a unique subset of the set of black teachers.

As was discussed in the literature review, a majority of the previous studies examined the impact of current teacher's experience and level of education on achievement but were unable to determine the direct effect of previous characteristics. Equation (3-1) was thus re-estimated with only current year variables to determine if the omission of lagged variables significantly altered the coefficients or signs of the current variables.

$$\text{(3-2)} \quad CS76 = 6.92 + \underset{(42.20)}{.841CS75} + \underset{(8.36)}{.145IQ} + \underset{(1.20)}{.077Texp76} - \underset{(-.77)}{.001Texp76^2}$$

$$- \underset{(-1.85)}{.639Hdeg76} + \underset{(8.69)}{.183MeanCS76} - \underset{(-1.22)}{.376ClassSize76}$$

$$- \underset{(2.07)}{.187Attend76} + \underset{(4.50)}{.085TNW76} .$$

t-statistics appear in parentheses below each coefficient; $R^2 = .900$; $n = 1,032$.

Comparison of (3-1) and (3-2) revealed that with the exception

[9] The schools were highly segregated during this period. In 1976, 75 percent of the whites attended schools with less than 10 percent non-white pupils. In 1975, 85 percent were in schools with less than 11 percent non-white students.

of the school level variables, the omission of previous variables did not alter the signs or coefficients of the current variables. Nonetheless, the changes in the school level variables were dramatic. The percentage of student attendance in the 1976 school (Attend76), significantly negative in equation (3-1), became significantly positive in equation (3-2). The coefficient on the percentage of non-white teachers in the 1976 school (TNW76) became statistically significant in equation (3-2) and increased from .003 to .085. These results reinforce the view that multi-collinearity may be a problem. The simple correlation between Attend76 and Attend75 is .778, while the correlation between TNW76 and TNW75 is .799.

In order to test for unmeasured school or neighborhood[10] characteristics, the 1976 school was incorporated as a dummy explanatory variable in estimating the complete structural equation (equation (2-17)). Inclusion of such a variable represents the worst possible case for the teaching resources. Since the school variable may be picking up both measured and unmeasured characteristics, any correlation between teaching resources and particular schools may be reflected in the coefficients on the school dummies.

A comparison of the coefficients on experience and level of education with and without the school dummy variable appears in Table (3-3). The coefficient on 1975 teacher's experience was positive and

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[10] A school dummy variable would reflect neighborhood characteristics only if students attended schools near their homes (i.e., were not bused).

TABLE 3-3

White Sample: Comparison of Experience and Level of Education Coefficients With and Without School 76 as a Dummy Variable

(t-statistics in parentheses)

Experience	Without School 76 (Equation (3-1))	With School 76[a]
Texp76	.044 (.67)	.119 (.72)
$Texp76^2$	-.0001 (-.10)	.001 (.44)
Texp75	.136 (2.69)	.268 (2.05)
$Texp75^2$	-.003 (-3.18)	-.003 (-2.12)
Texp74	.091 (1.56)	-.027 (-.19)
$Texp74^2$	-.002 (-1.77)	-.002 (-1.63)
Texp73	.028 (.59)	.029 (.21)
$Texp73^2$	-.0009 (-.84)	.001 (.66)
Level of Education		
Hdeg76	-.715 (-2.03)	-3.80 (-1.23)
Hdeg75	.660 (1.67)	-3.99 (-1.26)
Hdeg74	-.577 (-1.51)	1.05 (.33)
Hdeg73	-.569 (-1.38)	-.532 (-.15)

[a]The number of unique schools equals 45.

significant in both equations; however, it was larger when 1976 school was a variable. The 1976 teacher's level of education was negative in both regressions but it was statistically insignificant when 1976 school was a variable. The complete regression appears in Table (B-4) of Appendix B.

Insignificant variables. A large number of variables did not appear to have a statistically significant impact on white achievement. The sex, recency of degree and undergraduate college rating of the current and three previous instructors were insignificant predictors of achievement. Four dummy variables, taking on values of one if the instructors had baccalaureate degrees in education, were not relevant. Interaction of the student's IQ with each of the four teachers' years of experience, level of education, and undergraduate college rating produced no significant results. IQ was divided into four segments; low, middle, high and exceptional, and interacted with experience, level of education, and undergraduate college rating of all four instructors. None of these variables were statistically significant. The interaction of lagged achievement score, CS75, with 1976 teacher experience, level of education, and undergraduate college rating did not yield significant results suggesting that these three characteristics were not relevant to the initial stock of knowledge.

The three past years of class mean achievement (MeanCS73-75) were insignificant predictors of white achievement. The standard deviation of class achievement in every year (SDCS73-76) and the class size in the first two years were similarly unimportant.

The insignificant school-level variables included the percentage of teacher attendance in the student's school (TAttend74-76), the pupil/teacher ratio (Ratio74-76) in the student's school, and the enrollment in the student's school (Schsize74-76). Segregated residential housing patterns and eligibility definitions disallowed the inclusion of Title I variables (see note 2). Only a small number of whites (e.g., six percent in 1976) were eligible for these compensatory programs.

Reduced form equation estimates. Direct effects of current and previous inputs are observable from the structural equation. The reduced form (equations (2-18) and (2-18a)) permits the estimation of the indirect effects of an input through previous achievement and provides the best measure of an input's total contribution. The identification problem was solved by searching the parameter space for gamma, constraining it to lie between zero and one, and selecting as the final set of estimates that regression which had the smallest sum of squared errors. The transmission parameter, gamma, was constrained in this fashion since in all three samples the direct estimate of gamma, the coefficient on CS75 in the structural equation, was less than one. The coefficient on CS75 was .849 for whites, .802 for eighth grade blacks, and .771 for seventh grade blacks. As a check on the consistency of gamma, it was hoped that the value of gamma from the final reduced form equation would closely approximate the direct estimate of gamma from the structural equation.

A brief explanation of the steps involved in estimating the reduced form equations will help clarify the distinctions between equations (2-18) and (2-18a). Equation (2-18a) was estimated to determine the value of gamma which yielded the smallest sum of squared errors. Values of gamma ranging from .1 to .99 in intervals of .1 were tested. Equation (2-18), however, yields the direct and indirect effects. The results from equation (2-18a) were thus "transformed" to conform to equation (2-18). For example, a model with only one set of inputs (T_{7i}) consistent with equation (2-18a) would be as follows:

$$\begin{aligned}\text{Dependent Variable} = {} & \beta_0(\gamma^3 T_{73} + \gamma^2 T_{74} + \gamma T_{75} + T_{76}) \\ & + \beta_2(\gamma^2 T_{73} + \gamma T_{74} + T_{75}) \\ & + \beta_3(\gamma T_{73} + T_{74}) \\ & + \beta_4(T_{73}) .\end{aligned}$$

It is important to note that T_{73} contributes to the dependent variable via four channels (three indirect plus one direct) while T_{76} works only through the direct (unfiltered) channel. The objective is to measure the cumulative (direct and indirect) effects of each T_{7i}. Denote these cumulative effects by $\hat{\delta}' = [\hat{\delta}_{73}, \hat{\delta}_{74}, \hat{\delta}_{75}, \hat{\delta}_{76}]$, where $\hat{\delta}_{7i}$ is the coefficient of T_{7i}. In matrix form $\hat{\delta}$ is computed as follows:

$$\begin{bmatrix}\hat{\delta}_{73}\\ \hat{\delta}_{74}\\ \hat{\delta}_{75}\\ \hat{\delta}_{76}\end{bmatrix} = \underbrace{\begin{bmatrix}\gamma^3 & \gamma^2 & \gamma & 1\\ \gamma^2 & \gamma & 1 & 0\\ \gamma & 1 & 0 & 0\\ 1 & 0 & 0 & 0\end{bmatrix}}_{\Gamma} \underbrace{\begin{bmatrix}\hat{\beta}_0\\ \hat{\beta}_2\\ \hat{\beta}_3\\ \hat{\beta}_4\end{bmatrix}}_{\hat{\beta}}$$

The estimated coefficients and variance-covariance matrix of $\hat{\beta}$ are known. What is desired are the coefficients and variance-covariance matrix of $\hat{\delta}$. Since

$$\hat{\delta} = \Gamma\hat{\beta}$$

then

$$\text{var-cov } \hat{\delta} = \Gamma(\text{var-cov } \hat{\beta})\Gamma'$$

by standard statistical results (Goldberger, 1964).[11] Let

$$\text{var-cov } \hat{\beta} = \Omega ,$$

then

$$\text{var-cov } \hat{\delta} = \Gamma\Omega\Gamma' .$$

The square roots of the diagonal elements, or the standard errors, divided into the coefficients, will thus yield (asymptotic) t-statistics for each input.

Table (3-4) provides reduced form equation estimates which are consistent with the grouping of terms in equation (2-18a). Table (3-5) gives a definition of these variables while Table (3-6) provides estimates of the reduced form consistent with equation (2-18). A discussion of Table (3-6) will be followed by a paragraph contrasting the structural and reduced form equation estimates.

Table (3-6) provides estimates of each input's direct and indirect contribution to the change in achievement. In terms of teaching

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[11] The relationship holds strictly only for the case in which Γ, rather than its estimate, appears. However, the relationship holds asymptotically.

TABLE 3-4

White Sample: Reduced Form Equation Estimates - Equation (2-18a)

Variables	Coefficients	t-statistics
Texpβ_0	-.018	-.187
Texpβ_2	.463*	2.47
Texpβ_3	-.406	-1.68
Texpβ_4	.124	.489
Texp$^2\beta_0$	.0003	.138
Texp$^2\beta_2$	-.0007	-.278
Texp$^2\beta_3$	-.002	-.919
Texp$^2\beta_4$	.002	.804
Hdegβ_0	-.015	-.028
Hdegβ_2	-2.57	-.638
Hdegβ_3	4.22	.787
Hdegβ_4	-4.89	-.861
CollegeRatingβ_0	6.43	1.53
CollegeRatingβ_2	-4.25	-.672
CollegeRatingβ_3	-2.58	-.445
Eddegβ_0	.513	.661
Eddegβ_2	-.175	-.174
Eddegβ_3	.218	.243
Tsexβ_0	.467	.780
Tsexβ_2	1.15	1.24
Tsexβ_3	-2.62*	-2.60

(cont.)

TABLE 3-4 (continued)

Variables	Coefficients	t-statistics
IQ Texpβ_1	-.004*	-2.35
IQ Texpβ_5	.005*	2.05
IQ Texpβ_6	-.002	-.814
IQ Hdegβ_1	.032	.768
IQ Hdegβ_5	-.056	-1.00
IQ Hdegβ_6	.046	.787
IQ CollegeRatingβ_1	-.056	-1.40
IQ CollegeRatingβ_5	.036	.594
IQ CollegeRatingβ_6	.025	.460
SDCSα_1	.394*	2.98
SDCSα_2	-.338	-1.49
SDCSα_3	-.426	-1.64
IQa	.112*	9.35
MeanCSα_1	.322*	7.79
MeanCSα_2	-.215*	-2.95
MeanCSα_3	.001	.020
MeanCSα_4	-.139	-1.72
ClassSizeα_1	-1.70*	-3.31
ClassSizeα_2	1.77*	2.38
ClassSizeα_3	.225	.325
ClassSizeα_4	.703	.924
Attendα_1	.100	.476

(cont.)

TABLE 3-4 (continued)

Variables	Coefficients	t-statistics
Attendə$_2$	.210	.657
Attendə$_3$	-.783*	-2.50
TAttendə$_1$	.233*	2.49
TAttendə$_2$	-.091	-.573
Schsizeə$_1$	-.002	-.614
Schsizeə$_2$	.007	.918
Ratioə$_1$	.552*	2.89
Ratioə$_2$	-.686*	-2.04
TNWə$_1$	.001	.027
TNWə$_2$	.050	.580

*Significant at the .05 level.

Dependent variable: $CS76-\gamma^4 CS72$; 1976 Composite Achievement score on Iowa Test of Basic Skills minus $(.93^4)$ 1972 Composite Achievement score on Iowa Test of Basic Skills. Constant = -64.15; R^2 = .566; n = 987, gamma = .93.

TABLE 3-5

White Sample: Reduced Form Equation
Variable Definitions

Variable	Definition
$Texp\beta_0$	$\gamma^3(Texp73) + \gamma^2(Texp74) + \gamma(Texp75) + Texp76$
$Texp\beta_2$	$\gamma^2(Texp73) + \gamma(Texp74) + Texp75$
$Texp\beta_3$	$\gamma(Texp73) + Texp74$
$Texp\beta_4$	$Texp73$
$Texp^2\beta_0$	$\gamma^3(Texp73^2) + \gamma^2(Texp74^2) + \gamma(Texp75^2) + Texp76^2$
$Texp^2\beta_2$	$\gamma^2(Texp73^2) + \gamma(Texp74^2) + Texp75^2$
$Texp^2\beta_3$	$\gamma(Texp73^2) + Texp74^2$
$Texp^2\beta_4$	$Texp73^2$
$Hdeg\beta_0$	$\gamma^3(Hdeg73) + \gamma^2(Hdeg74) + \gamma(Hdeg75) + Hdeg76$
$Hdeg\beta_2$	$\gamma^2(Hdeg73) + \gamma(Hdeg74) + Hdeg75$
$Hdeg\beta_3$	$\gamma(Hdeg73) + Hdeg74$
$Hdeg\beta_4$	$Hdeg73$
$CollegeRating\beta_0$	$\gamma^3(Rating73) + \gamma^2(Rating74) + \gamma(Rating75)$
$CollegeRating\beta_2$	$\gamma^2(Rating73) + \gamma(Rating74)$
$CollegeRating\beta_3$	$\gamma(Rating73)$
$Eddeg\beta_0$	$\gamma^3(Eddeg73) + \gamma^2(Eddeg74) + \gamma(Eddeg75)$
$Eddeg\beta_2$	$\gamma^2(Eddeg73) + \gamma(Eddeg74)$
$Eddeg\beta_3$	$\gamma(Eddeg73)$
$Tsex\beta_0$	$\gamma^3(Tsex73) + \gamma^2(Tsex74) + \gamma(Tsex75)$
$Tsex\beta_2$	$\gamma^2(Tsex73) + \gamma(Tsex74)$
$Tsex\beta_3$	$\gamma(Tsex73)$

(cont.)

TABLE 3-5 (continued)

Variable	
IQ Texpβ_1	$\gamma^3(IQ*Texp73) + \gamma^2(IQ*Texp74) + \gamma(IQ*Texp75)$
IQ Texpβ_5	$\gamma^2(IQ*Texp73) + \gamma(IQ*Texp74)$
IQ Texpβ_6	$\gamma(IQ*Texp73)$
IQ Hdegβ_1	$\gamma^3(IQ*Hdeg73) + \gamma^2(IQ*Hdeg74) + \gamma(IQ*Hdeg75)$
IQ Hdegβ_5	$\gamma^2(IQ(Hdeg73) + \gamma(IQ*Hdeg74)$
IQ Hdegβ_6	$\gamma(IQ*Hdeg73)$
IQ CollegeRatingβ_1	$\gamma^3(IQ*Rating73) + \gamma^2(IQ*Rating74) + \gamma(IQ*Rating75)$
IQ CollegeRatingβ_5	$\gamma^2(IQ*Rating73) + \gamma(IQ(Rating74)$
IQ CollegeRatingβ_6	$\gamma(IQ*Rating73)$
SDCS∂_1	$\gamma^3(SDCS73) + \gamma^2(SDCS74) + \gamma(SDCS75)$
SDCS∂_2	$\gamma^2(SDCS73) + \gamma(SDCS74)$
SDCS∂_3	$\gamma(SDCS73)$
IQa	$(\gamma^3 + \gamma^2 + \gamma + 1)IQ$
MeanCS∂_1	$\gamma^3(MeanCS73) + \gamma^2(MeanCS74) + \gamma(MeanCS75) + MeanCS76$
MeanCS∂_2	$\gamma^2(MeanCS73) + \gamma(MeanCS74) + MeanCS75$
MeanCS∂_3	$\gamma(MeanCS73) + MeanCS74$
MeanCS∂_4	MeanCS73
ClassSize∂_1	$\gamma^3(ClassSize73) + \gamma^2(ClassSize74) + \gamma(ClassSize75) + ClassSize76$
ClassSize∂_2	$\gamma^2(ClassSize73) + \gamma(ClassSize74) + ClassSize75$
ClassSize∂_3	$\gamma(ClassSize73) + ClassSize74$
ClassSize∂_4	ClassSize73
Attend∂_1	$\gamma^2(Attend74) + \gamma(Attend75) + Attend76$

(cont.)

TABLE 3-5 (continued)

Variable	Definition
$Attend\partial_2$	γ(Attend74) + Attend75
$Attend\partial_3$	Attend74
$TAttend\partial_1$	γ^2(TAttend74) + γ(TAttend75)
$TAttend\partial_2$	γ(TAttend74)
$Schsize\partial_1$	γ^2(Schsize74) + γ(Schsize75)
$Schsize\partial_2$	γ(Schsize74)
$Ratio\partial_1$	γ^2(Ratio74) + γ(Ratio75)
$Ratio\partial_2$	γ(Ratio74)
$TNW\partial_1$	γ(TNW75) + TNW76
$TNW\partial_2$	TNW75

TABLE 3-6

White Sample: Reduced Form Equation Estimates - Equation (2-18) Total Direct and Indirect Effects

Teaching Characteristics

Variables	Coefficients	t-statistics
Texp73	.132	.739
Texp74	.009	.048
Texp75	.447*	2.65
Texp76	-.018	-.187
$Texp73^2$	-.0006	-.365
$Texp74^2$	-.003	-1.43
$Texp75^2$	-.0004	-.264
$Texp76^2$	.0003	.138
Hdeg73	-3.20	-.719
Hdeg74	1.81	.435
Hdeg75	-2.59	-.641
Hdeg76	-.015	-.027
CollegeRating73	-.905	-.234
CollegeRating74	1.60	.381
CollegeRating75	5.98	1.53
Eddeg73	.464	.808
Eddeg74	.280	.428
Eddeg75	.477	.661

(cont.)

TABLE 3-6 (continued)

Variables	Coefficients	t-statistics
Tsex73	-1.06	-1.43
Tsex74	1.47*	2.26
Tsex75	.435	.780
TAttend74	.116	1.08
TAttend75	.217*	2.49
TNW75	.052	1.10
TNW76	.001	.027
IQ*Texp73	-.0008	-.550
IQ*Texp74	.001	.648
IQ*Texp75	-.003*	-2.35
IQ*Hdeg73	.020	.488
IQ*Hdeg74	-.024	-.599
IQ*Hdeg75	.030	.768
IQ*CollegeRating73	.009	.265
IQ*CollegeRating74	-.015	-.376
IQ*CollegeRating75	-.052	-1.40
	Ability	
IQ	.405*	9.35
	Peer Characteristics	
SDCS73	-.371*	-2.24
SDCS74	.026	.179

(cont.)

TABLE 3-6 (continued)

Variables	Coefficients	t-statistics
SDCS75	.367*	2.98
MeanCS73	-.065	-1.42
MeanCS74	.079	1.44
MeanCS75	.083	1.74
MeanCS76	.322*	7.79
ClassSize73	1.07	1.89
ClassSize74	.405	.803
ClassSize75	.191	.370
ClassSize76	-1.70*	-3.31
Attend74	.501*	-2.68
Attend75	.303	1.58
Attend76	.100	.476
Schsize74	.004	1.15
Schsize75	-.002	-.614
Ratio74	-.161	-.860
Ratio75	.513*	2.89
constant	-64.15	-3.34

*Significant at the .05 level.

Dependent variable: $CS76 - \gamma^4 CS72$; 1976 composite achievement score on the Iowa Test of Basic Skills (ITBS) minus $(.93^4)$1972 composite achievement score on ITBS. R^2 = .566, n = 987, gamma = .93.

characteristics, the cumulative effects of experience were significant for only one instructor (Texp75). The experience of the other three instructors was unimportant. Teachers' level of education was not significant in any of the years under study nor were the indirect effects of the college ratings and possession of an education degree significant predictors of the change in achievement.[12] The cumulative effects of ability (IQ) were significantly positive.

In terms of the peer group variables, 1975 classroom standard deviation (SDCS75) and 1976 classroom mean achievement (MeanCS76) were significant contributors to the change in achievement. The cumulative effects of classroom mean achievement in the previous two years (MeanCS74, MeanCS75) were also positive and approached statistical significance. Current year's classroom size was significantly negative but there was no lingering effect of earlier classroom sizes.

An examination of the school level variables showed that the direct and indirect effects of earliest year's attendance (Attend74) were significantly negative. As was true with the structural equation estimates, the sign on this variable is difficult to interpret and no

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[12] If the direct effects of an input were consistently insignificant across structural equations, that input's direct effect was not usually measured in the reduced form equations. Direct effects were included, even if the coefficients were statistically insignificant, if they were needed for the matrix inversion when transforming equation (2-18a) to equation (2-18). For example, the college rating variables (Ratings73-76) were never statistically significant in the structural equations. When estimating the reduced form equation the construction of the variables was such that the indirect effects were capturable while the direct effects were eliminated.

definitive conclusions regarding its impact can be made. One additional school level variable was significant. The 1975 school's pupil/teacher ratio (Ratio75) had a positive impact.

In contrasting the structural and reduced form equations (equation (3-1) and Table (3-6)), it can be seen that the direct estimate of gamma, or the coefficient on CS75, was slightly lower than the value of gamma which was consistent with the smallest error sum of squares (.849 versus .93). The direct estimates of gamma from the structural equation includes measurement error. If measurement error is uncorrelated across years, the lower estimate from the structural equation could be explained by errors in variables which would cause a downward bias in the coefficient.

Examination of the teaching inputs across equations showed fairly strong consistencies. The direct effect of 1975 teacher's experience was positive and significant (.136 Texp75). The cumulative effects were positive, significant, and greater than the direct effects (.447 Texp75). Current year teacher's experience (Texp76) was positive in the structural equation and negative in the reduced form; however, it was not statistically significant in either case. Current year teacher's level of education (Hdeg76) was negative in both equations but significant only in the structural equation. The direct effects of the interaction of ability (IQ) with four years of teacher inputs were never significant in the structural equations. The reduced form estimates further showed that the indirect effects were unimportant. Only one of these interaction variables was statistically significant. The same situation held for the nature of the teacher's degree (Eddeg73-75) and undergraduate college rating (Rating73-75). The direct effects were unimportant and the reduced from equation confirmed the insignificance of the indirect effects.

Classroom mean achievement (MeanCS76) was significantly positive across equations while current year's classroom size (ClassSize76) was consistently negative. The direct effect of classroom standard deviation was never significant for whites but the indirect effect of the first lagged year (SDCS75) became apparent in the reduced form equation. The percentage of school-level attendance (Attend75, Attend76) was negative in the current year and positive in the first lagged year in the structural equation. The cumulative effects of these variables were insignificantly positive in the reduced form; however, the cumulative effect of Attend74 was disturbingly negative. The final school-level variables of interest, the percentage of non-white teachers in the student's 1975 and 1976 school (TNW76, TNW75) were somewhat surprising. The current year variable, TNW76, was insignificant across equations. The direct effect of the first lagged year, TNW75, was significantly positive while the cumulative effects were positive but insignificant.

Black Eighth Graders

Following the same general outline established in the white sample, this section will first report various structural equation estimates. Four years of teachers' experience and level of education were included in all structural equations; but, with few exceptions, only those variables with t-statistics significant at the .05 level appear in the reported equations (see note 7). A discussion of various structural equation estimates will be followed by an examination of the variables which did not appear to significantly effect student achievement. The section will conclude with the results of estimating the reduced form equations (equations (2-18) and (2-18a)).

Equations (3-3), (3-4), and Table (B-8) provide estimates of the structural equation. The reduced form equation estimates and variable definitions appear in Tables (3-9), (3-10), and (3-11). Frequencies on teachers' experience and level of education appear in Tables (B-5) and (B-6). Variable definitions, means, and standard deviations appear in Table (3-7). A complete list of variable definitions can be found in Table (2-1) of Chapter 2.

Structural equation estimates. The estimated structure of equation (2-17) is presented in equation (3-3). Inclusion of four years of school and peer resources illustrated that variables which were significant predictors of white achievement were not necessarily good predictors of black eighth grade achievement. Similarly, insignificant variables in the white equation were often significant for black eighth graders.

TABLE 3-7

Black Eighth Grade Sample: Variable Definitions, Means, and Standard Deviations

Variable	Mean	Standard Deviation	Definition
CS76	78.57	14.19	1976 Iowa Test of Basic Skills (ITBS) composite score
CS75	69.76	12.69	1975 ITBS composite score
IQ	92.26	11.81	Stanford-Binet Intelligence Test score
Texp76	14.01	10.13	Years of teaching experience - 1976 instructor
Texp75	11.57	8.90	Years of teaching experience - 1975 instructor
Texp74	10.60	8.82	Years of teaching experience - 1974 instructor
Texp73	10.70	9.80	Years of teaching experience - 1973 instructor
Hdeg76	.356		Level of education - 1976 instructor =0 if B.A. =1 if M.A., Ed. Spec. or Ph.D.
Hdeg75	.274		Level of education - 1975 instructor
Hdeg74	.209		Level of education - 1974 instructor
Hdeg73	.228		Level of education - 1973 instructor
MeanCS76	75.56	7.77	1976 class mean on ITBS
MeanCS75	67.11	6.85	1975 class mean on ITBS
SDCS76	12.48	2.32	1976 class standard deviation on ITBS
Title76	.950		1976 Title I code =1 if eligible for compensatory programs =0 if otherwise

(cont.)

TABLE 3-7 (continued)

Variable	Mean	Standard Deviation	Definition
TitleIS76	256.10	110.72	Number of students enrolled in compensatory programs - 1976 school
TitleIS75	216.82	96.46	Number of students enrolled in compensatory programs - 1975 school
TitleIS74	167.11	77.79	Number of students enrolled in compensatory programs - 1974 school
Attend76	91.55	2.03	Percentage student attendance - 1976 school
Schsize76	564.07	184.73	1976 school enrollment
Ratio76	23.28	3.30	1976 school pupil/teacher ratio
Ratio75	26.35	3.08	1975 school pupil/teacher ratio

$$(3\text{-}3)\quad CS76 = -61.07 + \underset{(25.74)}{.802CS75} + \underset{(6.27)}{.193IQ} + \underset{(.04)}{.004Texp76} - \underset{(-.15)}{.0004Texp76^2}$$

$$- \underset{(-.50)}{.057Texp75} + \underset{(.77)}{.002Texp75^2} + \underset{(.33)}{.036Texp74} - \underset{(-.15)}{.0004Texp74^2}$$

$$+ \underset{(1.79)}{.167Texp73} - \underset{(-2.06)}{.005Texp73^2} + \underset{(1.64)}{.979Hdeg76} + \underset{(2.34)}{1.51Hdeg75}$$

$$+ \underset{(1.61)}{1.19Hdeg74} + \underset{(1.32)}{.949Hdeg73} + \underset{(11.41)}{.509MeanCS76} - \underset{(-4.70)}{.240MeanCS75}$$

$$- \underset{(-1.65)}{.198SDCS76} + \underset{(1.53)}{2.51Title76} + \underset{(2.22)}{.010TitleIS76}$$

$$- \underset{(-2.55)}{.011TitleIS75} + \underset{(2.11)}{.010TitleIS74} + \underset{(2.44)}{.358Attend76}$$

$$- \underset{(-3.04)}{.007Schsize76} + \underset{(1.71)}{.178Ratio76} + \underset{(2.75)}{.265Ratio75}$$

t-statistics appear in parentheses below each coefficient; $R^2 = .799$; $n = 742$.

The coefficients on experience and level of education differed slightly from the coefficients in the white sample. The signs of the teacher experience[13] coefficients were the expected pattern (positive on the linear term and negative on the squared term indicating diminishing returns) for three of the four years; yet, the t-statistics were just barely significant in only one case, that of the 1973 instructor. The 1975 instructor's experience was negative while the squared term was positive even though both terms were statistically

[13] Regressions omitting the squared experience term were inferior to the reported results.

insignificant. The pattern on level of education was somewhat more interesting. Possession of a Master's, Education Specialist, or Doctor's degree had a consistently positive effect on black eighth grade achievement. The only coefficient significant at the .05 level was on the 1975 instructor; however, 1976 and 1974 instructors' level of education were significant at the .10 level.

The coefficients on the peer group variables were very different from the white sample. The coefficient on 1976 classroom mean achievement was positive but was three times as large as the white coefficient. A ten point increase in classroom mean achievement implied a five month gain in black eighth grade achievement. The coefficient on 1975 classroom mean was also statistically significant but disturbingly negative. Standard deviation of 1976 classroom achievement had a slightly negative effect implying, at least in terms of achievement, more homogenous classrooms were desirable for eighth grade blacks.

Various Title I variables were significant predictors of eighth grade black achievement. If the student was eligible for Title I compensatory programs in 1976 (Title76), a positive effect on achievement resulted. Two related points should be made explicit concerning Title I eligibility variables. Over 90 percent of black eighth graders were eligible for these programs in the four years examined. Title I eligibility variables were thus highly correlated across years (see Table (B-7) of Appendix B). The variable was introduced primarily due to its possible interpretation as a family background variable since eligibility was determined by the number of school-age children in the school attendance area receiving Aid to Families with Dependent Children (AFDC). The coefficient could also be interpreted as simply the positive effect of the compensatory programs. A precise interpretation of the meaning of the coefficient is difficult. The number of students actually enrolled in Title I programs in the student's school (TitleIS74-76) was significant for each year the data were available. TitleIS76 and TitleIS74 had significantly positive effects while TitleIS75 was significantly negative. Again the problem of high correlation across years arises; not only are many black students served by these programs, but a high percentage also enroll in the same school from year to year.

Three additional school-level variables were significant. The percentage of attendance in the 1976 school (Attend76) had a significantly positive effect implying the presence of peers was important for eighth grade blacks. The enrollment of the 1976 school (Schsize76) had a deleterious impact on achievement. The coefficients of the pupil/teacher ratio in the 1976 and 1975 school (Ratio76, Ratio75) were both positive and significant at the .10 level.

Equation (3-3) was re-estimated with only current year variables to determine if the omission of the lagged variables significantly altered the coefficients or signs of the current variables.

$$(3\text{-}4)\quad \text{CS76} = -57.10 + \underset{(26.40)}{.752\text{CS75}} + \underset{(6.75)}{.200\text{IQ76}} - \underset{(-.33)}{.032\text{Texp76}}$$

$$+ \underset{(.12)}{.0003\text{Texp76}^2} + \underset{(2.39)}{1.37\text{Hdeg76}} + \underset{(11.29)}{.44\text{MeanCS76}} - \underset{(-2.18)}{.249\text{SDCS76}}$$

$$+ \underset{(1.66)}{2.71\text{Title76}} + \underset{(1.35)}{.005\text{TitleIS76}} + \underset{(2.26)}{.304\text{Attend76}}$$

$$- \underset{(-2.85)}{.005\text{Schsize76}} + \underset{(2.69)}{.259\text{Ratio76}}$$

t-statistics appear in parentheses below each coefficient; $R^2 = .782$; $n = 772$.

Comparison of (3-3) and (3-4) revealed only slight differences in signs and coefficients. Current year teacher's experience and experience squared were now negative and positive, respectively. Neither of these variables was statistically significant in either equation, however. The current year instructor's level of education did become significant in equation (3-4). The coefficient was 1.37 in contrast to .979 in equation (3-3). The coefficient on the number of Title I students enrolled in the 1976 school (TitleIS76) dropped from .010 in equation (3-3) to .005 in equation (3-4), while the 1976 school's pupil/teacher ratio (Ratio76) jumped from .178 in equation (3-3) to .259 in equation (3-4). Overall, the changes in these coefficients are minor and do not significantly alter the previous interpretation of the variables.

In order to test for unmeasured school or neighborhood characteristics, the 1976 school was introduced as a dummy explanatory variable in the estimation of the complete structural equation (equation

(2-17)). As was discussed in the previous section on white students, any correlation between teaching characteristics and schools may be reflected in the coefficients on the school dummies. A comparison of the coefficients on experience and level of education with and without the school variable appears in Table (3-8). The coefficients on 1975 teachers' characteristics changed the most. Experience (Texp75) was initially negative and insignificant but become positive with the introduction of the school dummies. Level of education (Hdeg75), however, became insignificant when 1976 school was a variable. The complete regression appears in Table (B-8) of Appendix B.

Insignificant variables. A great many variables did not appear to have a statistically significant impact on black achievement. The teacher characteristics and interactions between IQ and teaching characteristics will be discussed first, followed by peer and school-level variables.

The sex, recency of degree, and undergraduate college rating of the current and three previous instructors were insignificant predictors of achievement. Four dummy variables, taking on values of one if the instructors had baccalaureate degrees in education, were also unimportant. Interaction of the student's IQ with each teacher's years of experience, level of education, and undergraduate college rating yielded no significant results. As was the case with the white sample, IQ was divided into four segments - low, middle, high, and exceptional - and interacted with experience, level of education and undergraduate college rating of each instructor. None of these variables was statistically

TABLE 3-8

Black Eighth Grade Sample: Comparison of Experience and Level of Education Coefficients With and Without School 1976 as a Dummy Variable

(t-statistics in parentheses)

Experience	Without School 76 (Equation (3-3))	With School 76[b]
Texp76	.004 (.04)	.149 (.52)
$Texp76^2$	-.0004 (-.15)	-.0006 (-.16)
Texp75	-.057 (-.50)	1.00 (2.96)
$Texp75^2$	.002 (.77)	-.004 (-1.03)
Texp74	.036 (.33)	.264 (.91)
$Texp74^2$	-.0004 (-.15)	-.002 (-.64)
Texp73	.167 (1.79)	-.149 (-.49)
$Texp73^2$	-.005 (-2.06)	-.003 (-1.18)
Level of Education		
Hdeg76	.979 (1.64)	6.94 (1.41)
Hdeg75	1.51 (2.34)	.803 (.15)
Hdeg74	1.19 (1.61)	4.23 (.72)
Hdeg73	.949 (1.32)	-.191 (-.03)

[b]The number of unique schools equals 62.

significant. The interaction of lagged achievement score, CS75, with 1976 teacher experience, level of education, and undergraduate college rating did not produce significant results again suggesting these three characteristics were not relevant to the initial stock of knowledge.

The first two years of classroom mean score (MeanCS73-74) were unimportant predictors of black eighth grade achievement. All lagged years of classroom standard deviation (SDCS73-76) were similarly insignificant. Classroom size dummy variables, taking on values of one if classroom size exceeded 30, were entered for each of the four years, yet none proved significant. Two alternative configurations of classroom size (class size = 1 if > 35, = 0 if ≤ 35 and class size = "small" if ≤ 25, class size = "medium" if 25 < x ≤ 29, class size = "large" if 29 < x ≤ 32, class size = "crowd" if > 32) also failed to be significant predictors of black eighth grade achievement.

The insignificant school-level variables included the percentage of teacher attendance in the student's school (TAttend74-76), lagged years of the school's student attendance (Attend74-75) and enrollment (Schsize74-75), and the earliest school's pupil/teacher ratio (Ratio74). The percentage of non-white teachers in the student's school (TNW75-76) was also insignficant; however, most black eighth graders were enrolled in schools with very high percentages of non-white instructors.

Reduced form equation estimates. The reduced form equations (2-18) and (2-18a) were estimated in the same manner was was done for the white sample. The only distinction across samples involved the inclusion or exclusion of the direct effects of various variables depending upon their significance in the structural equations (see note 12). Table (3-9) provides reduced from equation estimates which are consistent with the grouping of terms in equation (2-18a). Table (3-10) supplies the definitions of these variables while Table (3-11) provides estimates corresponding to equation (2-18). A discussion of Table (3-11) will be followed by a comparison of the structural and reduced form equation estimates.

Table (3-11), which provides estimates of each input's direct and indirect contribution, illustrates how few variables were significant predictors of black eighth grade achievement growth. In terms of teaching characteristics, the cumulative effects of experience, level of education, undergraduate college rating, nature of degree, and sex were insignificant for all four instructors. The cumulative effects of ability (IQ) were, as in the white sample, significantly positive.

Two peer group variables were important in explaining achievement growth. Current year classroom mean achievement (MeanCS76) was strongly positive. The indirect effects of lagged year's classroom size (ClassSize75) were significantly negative. The only significant school-level variable was the percentage of non-white teachers in the student's 1975 school (TNW75). This variable was a positive predictor of achievement growth.

In comparing the structural and reduced form equations (equation (3-3) and Table (3-11), it can be seen that the direct estimate of gamma, or the coefficient on CS75, was again lower than the value of gamma consistent with the smallest error sum of squares (.802 versus

TABLE 3-9

Black Eighth Grade Sample: Reduced Form Equation Estimates - Equation (2-18a)

Variables	Coefficients	t-statistics
Texpβ_0	.423	1.07
Texpβ_2	-.026	-.051
Texpβ_3	-.157	-.307
Texp$^2\beta_0$	-.002	-.592
Texp$^2\beta_2$	-.001	-.218
Texp$^2\beta_3$	.0006	.120
Hdegβ_0	.668	.922
Hdegβ_2	.886	.146
Hdegβ_3	-.441	-.048
Hdegβ_4	-7.52	-.788
CollegeRatingβ_0	-1.40	-.220
CollegeRatingβ_2	-2.29	-.259
CollegeRatingβ_3	3.77	.423
Eddegβ_0	-.059	-.061
Eddegβ_2	-.415	-.307
Eddegβ_3	-.574	-.457
Tsexβ_0	1.18	1.14
Tsexβ_2	-.976	-.714
Tsexβ_3	-.633	-.488
IQ Texpβ_1	-.003	-.907

(cont.)

TABLE 3-9 (continued)

Variables	Coefficients	t-statistics
IQ Texpβ_5	.001	.260
IQ Texpβ_6	.0004	.090
IQ Hdegβ_1	.0003	.005
IQ Hdegβ_5	-.029	-.067
IQ Hdegβ_6	.119	1.04
IQ CollegeRatingβ_1	.019	.287
IQ CollegeRatingβ_5	.023	.250
IQ CollegeRatingβ_6	-.030	-.316
ClassSize∂_1	-1.87*	-2.40
ClassSize∂_2	1.06	.982
ClassSize∂_3	1.08	1.07
IQa	.130*	7.27
MeanCS∂_1	.630*	10.98
MeanCS∂_2	-.551	-5.78
MeanCS∂_3	.012	.123
MeanCS∂_4	-.104	-1.01
SDCS∂_1	-.027	-.181
SDCS∂_2	.268	1.05
SDCS∂_3	-.336	-1.14
SDCS∂_4	.326	1.10
Attend∂_1	.343	1.55
Attend∂_2	-.491	-1.40

(cont.)

TABLE 3-9 (continued)

Variables	Coefficients	t-statistics
$Attenda_3$	-.085	-.255
$TAttenda_1$	-.301	-1.33
$TAttenda_2$	.577	1.55
$Schsizea_1$	-.003	-.837
$Schsizea_2$	.0005	.066
$Schsizea_3$	.003	.648
$Ratioa_1$	.161	1.03
$Ratioa_2$	.066	.285
$Ratioa_3$	.145	.552
$TNWa_1$	.049*	2.07
$TitleISa_1$	.008	1.55
$TitleISa_2$	-.009	-1.08
$TitleISa_3$	.004	.404

*Significant at the .05 level.

Dependent variable: $CS76 - \gamma^4 CS72$; 1976 Composite Achievement score on Iowa Test of Basic Skills minus $(.90^4)$1972 Composite Achievement score on Iowa Test of Basic Skills. Constant = -55.72; R^2 = .493; n = 751; gamma = .90.

TABLE 3-10

Black Eighth Grade Sample: Reduced Form Equation Variable Definitions

Variables	Definition
$Texp\beta_0$	$\gamma^3(Texp73) + \gamma^2(Texp74) + \gamma(Texp75)$
$Texp\beta_2$	$\gamma^2(Texp73) + \gamma(Texp74)$
$Texp\beta_3$	$\gamma(Texp73)$
$Texp^2\beta_0$	$\gamma^3(Texp73^2) + \gamma^2(Texp74^2) + \gamma(Texp75^2)$
$Texp^2\beta_2$	$\gamma^2(Texp73^2) + \gamma(Texp74^2)$
$Texp^2\beta_3$	$\gamma(Texp73^2)$
$Hdeg\beta_0$	$\gamma^3(Hdeg73) + \gamma^2(Hdeg74) + \gamma(Hdeg75) + Hdeg76$
$Hdeg\beta_2$	$\gamma^2(Hdeg73) + \gamma(Hdeg74) + Hdeg75$
$Hdeg\beta_3$	$\gamma(Hdeg73) + Hdeg74$
$Hdeg\beta_4$	Hdeg73
$CollegeRating\beta_0$	$\gamma^3(Rating73) + \gamma^2(Rating74) + \gamma(Rating75)$
$CollegeRating\beta_2$	$\gamma^2(Rating73) + \gamma(Rating74)$
$CollegeRating\beta_3$	$\gamma(Rating73)$
$Eddeg\beta_0$	$\gamma^3(Eddeg73) + \gamma^2(Eddeg74) + \gamma(Eddeg75)$
$Eddeg\beta_2$	$\gamma^2(Eddeg73) + \gamma(Eddeg74)$
$Eddeg\beta_3$	$\gamma(Eddeg73)$
$Tsex\beta_0$	$\gamma^3(Tsex73) + \gamma^2(Tsex74) + \gamma(Tsex75)$
$Tsex\beta_2$	$\gamma^2(Tsex73) + \gamma(Tsex74)$
$Tsex\beta_3$	$\gamma(Tsex73)$
$IQ\ Texp\beta_1$	$\gamma^3(IQ*Texp73) + \gamma^2(IQ*Texp74) + \gamma(IQ*Texp75)$

(cont.)

TABLE 3-10 (continued)

Variables	Definition
IQ Texpβ_5	γ^2(IQ*Texp73) + γ(IQ*Texp74)
IQ Texpβ_6	γ(IQ*Texp73)
IQ Hdegβ_1	γ^3(IQ*Hdeg73) + γ^2(IQ*Hdeg74) + γ(IQ*Hdeg75)
IQ Hdegβ_5	γ^2(IQ*Hdeg73) + γ(IQ*Hdeg74)
IQ Hdegβ_6	γ(IQ*Hdeg73)
IQ CollegeRatingβ_1	γ^3(IQ*Rating73) + γ^2(IQ*Rating74) + γ(IQ*Rating75)
IQ CollegeRatingβ_5	γ^2(IQ*Rating73) + γ(IQ*Rating74)
IQ CollegeRatingβ_6	γ(IQ*Rating73)
ClassSize∂_1	γ^3(ClassSize73) + γ^2(ClassSize74) + γ(ClassSize75)
ClassSize∂_2	γ^2(ClassSize73) + γ(ClassSize74)
ClassSize∂_3	γ(ClassSize73)
IQa	$(\gamma^3 + \gamma^2 + \gamma + 1)$IQ
MeanCS∂_1	γ^3(MeanCS73) + γ^2(MeanCS74) + γ(MeanCS75) + MeanCS76
MeanCS∂_2	γ^2(MeanCS73) + γ(MeanCS74) + MeanCS75
MeanCS∂_3	γ(MeanCS73) + MeanCS74
MeanCS∂_4	MeanCS73
SDCS∂_1	γ^3(SDCS73) + γ^2(SDCS74) + γ(SDCS75) + SDCS76
SDCS∂_2	γ^2(SDCS73) + γ(SDCS74) + SDCS75
SDCS∂_3	γ(SDCS73) + SDCS74
SDCS∂_4	SDCS73
Attend∂_1	γ^2(Attend74) + γ(Attend75) + Attend76
Attend∂_2	γ(Attend74) + Attend75

(cont.)

TABLE 3-10 (continued)

Variables	Definition
$Attend\partial_3$	Attend74
$TAttend\partial_1$	γ^2(TAttend74) + γ(TAttend75)
$TAttend\partial_2$	γ(Tattend74)
$Schsize\partial_1$	γ^2(Schsize74) + γ(Schsize75) + Schsize76
$Schsize\partial_2$	γ(Schsize74) + Schsize75
$Schsize\partial_3$	Schsize74
$Ratio\partial_1$	γ^2(Ratio74) + γ(Ratio75) + Ratio76
$Ratio\partial_2$	γ(Ratio74) + Ratio75
$Ratio\partial_3$	Ratio74
$TNW\partial_1$	γ(TNW75)
$TitleIS\partial_1$	γ^3(TitleIS74) + γ^2(TitleIS75) + TitleIS76
$TitleIS\partial_2$	γ^2(TitleIS74) + TitleIS75
$TitleIS\partial_3$	TitleIS74

TABLE 3-11

Black Eighth Grade Sample: Reduced Form Equation Estimates - Equation (2-18) Total Direct and Indirect Effects

Teaching Characteristics

Variables	Coefficients	t-statistics
Texp73	.145	.436
Texp74	.319	1.01
Texp75	.381	1.07
$Texp73^2$	-.002	-.693
$Texp74^2$	-.003	-.793
$Texp75^2$	-.002	-.592
Hdeg73	-6.71	-.920
Hdeg74	.897	.135
Hdeg75	1.48	.246
Hdeg76	.668	.922
CollegeRating73	.517	.092
CollegeRating74	-3.20	-.604
CollegeRating75	-1.26	-.220
Eddeg73	-.896	-1.03
Eddeg74	-.422	-.462
Eddeg75	-.053	-.061
Tsex73	-.498	-.557
Tsex74	.079	.094
Tsex75	1.06	1.14

(cont.)

TABLE 3-11 (continued)

Variables	Coefficients	t-statistics
TAttend74	.275	1.23
TAttend75	-.271	-1.33
TNW75	.044*	2.07
IQ*Texp73	-.0008	-.258
IQ*Texp74	-.001	-.426
IQ*Texp75	-.002	-.907
IQ*Hdeg73	.084	1.07
IQ*Hdeg74	-.026	-.362
IQ*Hdeg75	.0003	.005
IQ*CollegeRating73	.005	.098
IQ*CollegeRating74	.037	.646
IQ*CollegeRating75	.017	.287
	Ability	
IQ	.448*	7.27
	Peer Characteristics	
SDCS73	.220	1.08
SDCS74	-.117	-.578
SDCS75	.243	1.27
SDCS76	-.027	-.181
MeanCS73	-.080	-1.16
MeanCS74	.026	.418

(cont.)

TABLE 3-11 (continued)

Variables	Coefficients	t-statistics
MeanCS75	.016	.239
MeanCS76	.630*	10.98
ClassSize73	.479	.719
ClassSize74	-.552	-.816
ClassSize75	-1.68*	-2.40
Attend74	-.249	-1.11
Attend75	-.182	-.822
Attend76	.343	1.55
Schsize74	.0009	.343
Schsize75	-.002	-.703
Schsize76	-.003	-.837
Ratio74	.336	1.83
Ratio75	.212	1.39
Ratio76	.161	1.03
TitleIS74	.003	.437
TitleIS75	-.001	-.271
TitleIS76	.008	1.55
constant	55.72	-1.42

*Significant at the .05 level.

Dependent variable: $CS76 - \gamma^4 CS72$; 1976 composite achievement score on the Iowa Test of Basic Skills (ITBS) minus ($.90^4$) 1972 composite achievement score on ITBS. R^2 = .493; n = 751, gamma = .90.

.900). As was discussed in the section on white students, errors in variables biased downward the coefficient on CS75 in the structural equation.

Examination of the teaching inputs across equations showed strong consistencies. The direct effects of experience (Texp73, Texp74, Texp75 and Texp76) were insignificant in the structural equation; the cumulative effects were similarly unimportant. The direct effect of first lagged year's level of education (Hdeg75) was positive and significant. The cumulative effects were also positive but not significant at the .05 level. The direct effects of teacher's undergraduate college rating, sex, nature of degree, and teaching/IQ interactions were not important predictors of achievement. The reduced form estimates revealed that the indirect effects were likewise insignificant.

In terms of the peer group variables, the direct effect of current year classroom mean achievement (MeanCS76) was positive and significant in both cases. The first lagged year's (MeanCS75) direct effect was negative and significant. The cumulative effects, however, were positive but insignificant.

The direct effects of various school-level variables (TitleIS74, TitleIS75, TitleIS76, Attend76, Schsize76, Ratio75 and Ratio76) were important predictors of achievement yet the cumulative impact of these variables never reached statistical significance. In all cases, however, the signs on the coefficients were identical.

Black Seventh Graders

As was the case with the previous two samples, this section will first report various structural equation estimates. Four years of teachers' experience and level of education were included in all structural equations, regardless of their t-statistics. Of the remaining variables, only those with t-statistics significant at the .05 level appear in the reported equations (see note 7). The second part of the section will discuss those variables which did not appear to have an impact on black seventh grade achievement. Finally, the results of estimating the reduced form equations (equations (2-18) and (2-18a)) will be presented.

Equations (3-5), (3-6), and Table (B-12) provide estimates of the structural equation. The reduced form equation estimates and variable definitions appear in Tables (3-14), (3-15), and (3-16). Frequencies on teachers' experience and level of education appear in Tables (B-5) and (B-6) of Appendix B. Variable definitions, means and standard deviations appear in Table (3-12). A complete list of variable definitions can be found in Table (2-1) of Chapter 2.

Structural equation estimates. The estimated structure of equation (2-17) is presented in equation (3-5). Inclusion of four teachers' years of experience and level of education illustrated the unimportance of these variables in explaining black seventh grade achievement.

TABLE 3-12

Black Seventh Grade Sample: Variable Definitions, Means, and Standard Deviations

Variable	Mean	Standard Deviation	Definition
CS76	70.09	12.07	1976 Iowa Test of Basic Skills (ITBS) Composite Score
CS75	61.03	10.93	1975 ITBS Composite Score
IQ	91.95	10.93	Stanford-Binet Intelligence Test Score
Texp76	11.57	8.40	Years of experience - 1976 instructor
Texp75	12.57	8.72	Years of experience - 1975 instructor
Texp74	11.89	9.12	Years of experience - 1974 instructor
Texp73	10.61	10.17	Years of experience - 1973 instructor
Hdeg76	.217		Level of education - 1976 instructor =0 if B.A. =1 if M.A., Ed. Spec. or Ph.D.
Hdeg75	.220		Level of education - 1975 instructor
Hdeg74	.155		Level of education - 1974 instructor
Hdeg73	.117		Level of education - 1973 instructor
TitleIS76	260.57	131.05	Number of students enrolled in compensatory programs - 1976 school
Eddeg76	.756		1976 instructor =1 if degree in education =0 if otherwise
Eddeg75	.772		1975 instructor
MeanCS76	68.03	6.75	1976 class mean on ITBS
MeanCS75	58.42	6.04	1975 class mean on ITBS

(cont.)

TABLE 3-12 (continued)

Variable	Mean	Standard Deviation	Definition
SDCS76	11.01	1.89	1976 class standard deviation on ITBS
Schsize76	620.08	200.89	1976 school enrollment
Sex	.530		student's sex =1 if female =0 if male

(3-5) $$CS76 = -11.88 + \underset{(34.02)}{.771CS75} + \underset{(7.70)}{.162IQ} - \underset{(-.20)}{.014Texp76}$$

$$- \underset{(-.21)}{.0004Texp76^2} - \underset{(-2.42)}{.169Texp75} + \underset{(3.12)}{.006Texp75^2} + \underset{(.55)}{.039Texp74}$$

$$- \underset{(-.84)}{.001Texp74^2} - \underset{(-.62)}{.037Texp73} - \underset{(-.03)}{.00005Texp73^2} + \underset{(.12)}{.055Hdeg76}$$

$$+ \underset{(.91)}{.393Hdeg75} - \underset{(-1.83)}{.939Hdeg74} + \underset{(.18)}{.104Hdeg73} + \underset{(4.27)}{.007TitleIS76}$$

$$- \underset{(-3.37)}{1.41Eddeg76} - \underset{(-1.75)}{.75Eddeg75} + \underset{(14.10)}{.458MeanCS76} - \underset{(-5.79)}{.210MeanCS75}$$

$$+ \underset{(4.08)}{.402SDCS76} - \underset{(-3.56)}{.003Schsize76} + \underset{(1.88)}{.638Sex}$$

t-statistics are displayed below each coefficient; $R^2 = .769$; n = 1,241. The only significant experience coefficient was on the 1975 instructor. In this case the signs of the coefficients were the opposite of what was expected. The sign on the linear term was negative while the sign on the squared terms was positive.[14] None of the four instructors' education levels were relevant predictors of black seventh grade achievement. The coefficient on the 1974 instructor's level of education was the only variable which approached significance. Interestingly enough, the 1976 dummy variable indicating teachers' possession of a baccalaureate degree in education (Eddeg76) had a significantly negative impact on seventh grade achievement. This particular variable may have been a better proxy for the rigor of the instructor's undergraduate program than the Gourman undergraduate college ratings.

Three peer group variables were statistically significant. As was true for black eighth graders, the current class mean score

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[14]Regressions omitting the squared experience term were inferior to the reported results.

(MeanCS76) had a strong positive effect on achievement while the lagged year's (MeanCS75) influence was negative. A slight difference in the two black samples was found on the current class standard deviation coefficient (SDCS76). In the eighth grade a high standard deviation reduced achievement; the opposite was true for seventh graders.

In terms of the school level variables, current year's school size (Schsize76) had a negative effect on achievement while the number of enrolled Title I students (TitleIS76) had a positive effect.

Equation (3-5) was re-estimated with only current year variables to determine if the absence of the lagged variables significantly altered the coefficients or signs of the current variables.

$$(3\text{-}6)\quad \underset{}{CS76} = -23.94 + \underset{(29.46)}{.714CS75} + \underset{(7.60)}{.184IQ} - \underset{(-.91)}{.074Texp76} + \underset{(.57)}{.001Texp76^2}$$

$$+ \underset{(.35)}{.177Hdeg76} + \underset{(5.61)}{.011TitleIS76} - \underset{(-2.67)}{1.35Eddeg76} + \underset{(13.28)}{.454MeanCS76}$$

$$+ \underset{(3.50)}{.4125SDCS76} - \underset{(-4.85)}{.005Schsize76} + \underset{(1.93)}{.756Sex}$$

t-statistics appear in parentheses below each coefficient; $R^2 = .764$; $n = 939$. Comparison of (3-5) and (3-6) revealed that the omission of lagged variables did not significantly alter the signs or the coefficients of the current variables.

In order to test for unmeasured school or neighborhood characteristics, the 1976 school was introduced as a dummy variable in estimating the complete structural equation (equation (2-17)). A comparison of the coefficients on experience and level of education with and without the school dummy variable appears in Table (3-13). The coefficient on 1976 teacher's experience was initially negative; however, it was positive when 1976 school was a variable. A sign reversal was also

TABLE 3-13

Black Seventh Grade Sample: Comparison of Experience and Level of Education Coefficients With and Without School 1976 as a Dummy Variable

(t-statistics in parentheses)

Experience	Without School 76 (Equation (3-5))	With School 76[c]
Texp76	-.014 (-.20)	.415 (1.46)
$Texp76^2$	-.0004 (-.21)	-.005 (-1.33)
Texp75	-.169 (-2.42)	.156 (.61)
$Texp75^2$	.006 (3.12)	.001 (.48)
Texp74	.039 (.55)	-.035 (-.16)
$Texp74^2$	-.001 (-.84)	.004 (1.60)
Texp73	-.037 (-.62)	.441 (2.16)
$Texp73^2$	-.00005 (-.03)	-.002 (-1.01)
Level of Education		
Hdeg76	.055 (.12)	1.52 (.29)
Hdeg75	.393 (.91)	3.25 (.74)
Hdeg74	-.939 (-1.83)	-4.20 (-.80)
Hdeg73	.104 (.18)	-3.77 (-.52)

[c]The number of unique schools equals 68.

observed on 1975 teacher's experience. In the first structural equation the coefficient was significantly negative but it became positive with the introduction of the dummy variable. The sign on the 1973 teacher's experience, negative and insignificant in equation (3-5), became positive and significant when 1976 school was a variable. The complete regression appears in Table (B-12) of Appendix B.

Insignificant variables. A great many variables did not appear to significantly alter black seventh grade achievement. The sex, recency of degree, and undergraduate college rating of the current and three previous instructors were insignificant predictors of achievement. The 1973 and 1974 dummy variables representing baccalaureate degrees in education were also unimportant. Interaction of the student's IQ with each teacher's years of experience, level of education, and undergraduate college rating produced no significant results. The division of IQ into segments - low, middle, high and exceptional - and subsequent interaction with experience, level of education, and undergraduate college rating also yielded no meaningful results. The interaction of lagged achievement score, CS75, with 1976 teacher's experience, level of education, and undergraduate college rating again demonstrated that these characteristics were not relevant to the initial stock of knowledge.

The first two years of classroom mean score (MeanCS73-74) were insignificant predictors of black seventh grade achievement. All lagged years of classroom standard deviation (SDCS73-75) were similarly unimportant. Classroom size dummy variables, taking on values of one if classroom size exceeded 30, were tested for all years yet none proved significant. Additional configurations of classroom size (class size

= 1 if > 35, = 0 if ≤ 35 and class size = "small" if ≤ 23, class size = "medium" if 23 < x ≤ 28, class size = "large" if 28 < x ≤ 32, class size = "crowd" if > 32) also failed to be important predictors of seventh grade achievement.

The insignificant school-level variables were numerous. Each school's percentage of teacher attendance, percentage of student attendance, pupil/tacher ratio, and percentage of non-white teachers produced no discernable effect on student's score (however, most black seventh graders were enrolled in schools with very high percentages of non-white teachers). School size and number of enrolled Title I students in the 1974 and 1975 school were also not important predictors of seventh grade score.

Reduced form equation estimates. The reduced form equations (2-18) and (2-18a) were estimated in the same manner as the previous two samples. Table (3-14) displays reduced from equation estimates which are consistent with the grouping of variables in equation (2-18a). Table (3-15) supplies the variable definitions and Table (3-16) provides estimates comparable to equation (2-18). A discussion of Table (3-16) will be followed by a paragraph contrasting the structural and reduced from equation estimates.

Table (3-16) illustrates that the cumulative effects of teaching characteristics were not important contributors to black seventh grade achievement growth. The coefficients on experience, level of education, undergraduate college rating, and sex were insignificant for all four instructors. The cumulative effects of earliest teacher's level of

TABLE 3-14

Black Seventh Grade Sample: Reduced Form Equation Estimates - Equation (2-18a)

Variables	Coefficients	t-statistics
$Texp\beta_0$	.040	.341
$Texp\beta_2$	-.458	-1.39
$Texp\beta_3$	.164	.370
$Texp\beta_4$	.264	.678
$Texp^2\beta_0$	-.001	-.528
$Texp^2\beta_2$	.008	1.74
$Texp^2\beta_3$	-.001	-.322
$Texp^2\beta_4$	.0003	.075
$Hdeg\beta_0$	3.58	.545
$Hdeg\beta_2$	6.30	.607
$Hdeg\beta_3$	-27.21*	-1.97
$CollegeRating\beta_0$	-2.53	-.415
$CollegeRating\beta_2$	10.08	1.13
$CollegeRating\beta_3$	-9.01	-1.08
$Tsex\beta_0$	.009	.012
$Tsex\beta_2$	.172	.126
$Tsex\beta_3$	.837	.588
$IQ\ Texp\beta_1$	.002	.645
$IQ\ Texp\beta_5$	-.001	-.308
$IQ\ Texp\beta_6$	-.002	-.698

(cont.)

TABLE 3-14 (continued)

Variables	Coefficients	t-statistics
IQ Hdegβ_1	-.029	-.418
IQ Hdegβ_5	-.081	-.733
IQ Hdegβ_6	.265	1.79
IQ CollegeRatingβ_1	.015	.241
IQ CollegeRatingβ_5	-.087	-.919
IQ CollegeRatingβ_6	.095	1.09
ClassSize∂_1	.580	.763
ClassSize∂_2	.995	1.00
ClassSize∂_3	-1.56	-1.62
Eddegβ_0	-1.58*	-2.08
Eddegβ_2	.264	.254
Eddegβ_3	.846	.747
Eddegβ_4	-.121	-.095
IQ∂	.111*	5.53
Sex∂	.134	.874
MeanCS∂_1	.536*	9.88
MeanCS∂_2	-.314*	-3.45
MeanCS∂_3	-.280*	-2.67
MeanCS∂_4	.087	.809
SDCS∂_1	.382*	2.20
SDCS∂_2	-.357	-1.32
SDCS∂_3	.175	.620

(cont.)

TABLE 3-14 (continued)

Variables	Coefficients	t-statistics
SDCSa_4	-.254	-.869
Attenda_1	-.133	-.677
Attenda_2	.487	1.36
TAttenda_1	.220	1.20
TAttenda_2	-.130	-.486
Ratioa_1	.054	.403
Ratioa_2	-.039	-.174
Schsizea_1	-.013*	-4.62
Schsizea_2	.013*	2.89
Schsizea_3	.0002	.070
TNWa_1	.046*	2.10
TitleISa_1	.016*	4.29
TitleISa_2	-.014*	-2.15
TitleISa_3	-.006	-.599

*Significant at the .05 level.

Dependent variable: $CS76 - \gamma^4 CS72$; 1976 Composite Achievement score on Iowa Test of Basic Skills (ITBS) minus $(.90^4)$ 1972 Composite Achievement score on ITBS. Constant = -72.12; R^2 = .446; n = 838; gamma = .90.

TABLE 3-15

Black Seventh Grade Sample: Reduced Form Equation Variable Definitions

Variables	Definition
$Texp\beta_0$	$\gamma^3(Texp73) + \gamma^2(Texp74) + \gamma(Texp75) + Texp76$
$Texp\beta_2$	$\gamma^2(Texp73) + \gamma(Texp74) + Texp75$
$Texp\beta_3$	$\gamma(Texp73) + Texp74$
$Texp\beta_4$	Texp73
$Texp^2\beta_0$	$\gamma^3(Texp73^2) + \gamma^2(Texp74^2) + \gamma(Texp75^2) + Texp76^2$
$Texp^2\beta_2$	$\gamma^2(Texp73^2) + \gamma(Texp74^2) + Texp75^2$
$Texp^2\beta_3$	$\gamma(Texp73^2) + Texp74^2$
$Texp^2\beta_4$	$Texp73^2$
$Hdeg\beta_0$	$\gamma^3(Hdeg73) + \gamma^2(Hdeg74) + \gamma(Hdeg75)$
$Hdeg\beta_2$	$\gamma^2(Hdeg73) + \gamma(Hdeg74)$
$Hdeg\beta_3$	$\gamma(Hdeg73)$
$CollegeRating\beta_0$	$\gamma^3(Rating73) + \gamma^2(Rating74) + \gamma(Rating75)$
$CollegeRating\beta_2$	$\gamma^2(Rating73) + \gamma(Rating74)$
$CollegeRating\beta_3$	$\gamma(Rating73)$
$Tsex\beta_0$	$\gamma^3(Tsex73) + \gamma^2(Tsex74) + \gamma(Tsex75)$
$Tsex\beta_2$	$\gamma^2(Tsex73) + \gamma(Tsex74)$
$Tsex\beta_3$	$\gamma(Tsex73)$
IQ $Texp\beta_1$	$\gamma^3(IQ*Texp73) + \gamma^2(IQ*Texp74) + \gamma(IQ*Texp75)$
IQ $Texp\beta_5$	$\gamma^2(IQ*Texp73) + \gamma(IQ*Texp74)$
IQ $Texp\beta_6$	$\gamma(IQ*Texp73)$

(cont.)

TABLE 3-15 (continued)

Variables	Definition
IQ Hdegβ_1	γ^3(IQ*Hdeg73) + γ^2(IQ*Hdeg74) + γ(IQ*Hdeg75)
IQ Hdegβ_5	γ^2(IQ*Hdeg73) + γ(IQ*Hdeg74)
IQ Hdegβ_6	γ(IQ*Hdeg73)
IQ CollegeRatingβ_1	γ^3(IQ*Rating73) + γ^2(IQ*Rating74) + γ(IQ*Rating75)
IQ CollegeRatingβ_5	γ^2(IQ*Rating73) + γ(IQ*Rating74)
IQ CollegeRatingβ_6	γ(IQ*Rating73)
ClassSize∂_1	γ^3(ClassSize73) + γ^2(ClassSize74) + γ(ClassSize75)
ClassSize∂_2	γ^2(ClassSize73) + γ(ClassSize74)
ClassSize∂_3	γ(ClassSize73)
Eddegβ_0	γ^3(Eddeg73) + γ^2(Eddeg74) + γ(Eddeg75) + Eddeg76
Eddegβ_2	γ^2(Eddeg73) + γ(Eddeg74) + Eddeg75
Eddegβ_3	γ(Eddeg73) + Eddeg74
Eddegβ_4	Eddeg73
IQa	(γ^3 + γ^2 + γ + 1)IQ
Sexa	(γ^3 + γ^2 + γ + 1)Sex
MeanCS∂_1	γ^3(MeanCS73) + γ^2(MeanCS74) + γ(MeanCS75) + MeanCS76
MeanCS∂_2	γ^2(MeanCS73) + γ(MeanCS74) + MeanCS75
MeanCS∂_3	γ(MeanCS73) + MeanCS74
MeanCS∂_4	MeanCS73
SDCS∂_1	γ^3(SDCS73) + γ^2(SDCS74) + γ(SDCS75) + SDCS76
SDCS∂_2	γ^2(SDCS73) + γ(SDCS74) + SDCS75
SDCS∂_3	γ(SDCS73) + SDCS74

(cont.)

TABLE 3-15 (continued)

Variables	Definition
$SDCS\partial_4$	SDCS73
$Attend\partial_1$	γ^2(Attend74) + γ(Attend75)
$Attend\partial_2$	γ(Attend74)
$TAttend\partial_1$	γ^2(TAttend74) + γ(TAttend75)
$TAttend\partial_2$	γ(TAttend74)
$Ratio\partial_1$	γ^2(Ratio74) + γ(Ratio75)
$Ratio\partial_2$	γ(Ratio74)
$Schsize\partial_1$	γ^2(Schsize74) + γ(Schsize75) + Schsize76
$Schsize\partial_2$	γ(Schsize74) + Schsize75
$Schsize\partial_3$	Schsize74
$TNW\partial_1$	γ(TNW75)
$TitleIS\partial_1$	γ^2(TitleIS74) + γ(TitleIS75) + TitleIS76
$TitleIS\partial_2$	γ(TitleIS74) + TitleIS75)
$TitleIS\partial_3$	TitleIS74

TABLE 3-16

Black Seventh Grade Sample: Reduced Form Equation Estimates - Equation (2-18) Total Direct and Indirect Effects

Teaching Characteristics

Variables	Coefficients	t-statistics
Texp73	.071	.269
Texp74	-.214	-.736
Texp75	-.422	-1.38
Texp76	.040	.341
$Texp73^2$	.004	1.57
$Texp74^2$	.004	1.25
$Texp75^2$	.006*	1.97
$Texp76^2$	-.001	-.528
Hdeg73	-16.76	-1.76
Hdeg74	8.58	1.20
Hdeg75	3.22	.545
CollegeRating73	-1.79	-.318
CollegeRating74	7.01	1.28
CollegeRating75	-2.28	-.414
Eddeg73	-.300	-.365
Eddeg74	-.199	-.216
Eddeg75	-1.16	-1.41
Eddeg76	-1.58*	-2.08
Tsex73	.900	.994

(cont.)

TABLE 3-16 (continued)

Variables	Coefficients	t-statistics
Tsex74	.163	.163
Tsex75	.008	.012
TAttend74	.060	.406
TAttend75	.198	1.20
TNW75	.041*	2.10
IQ*Texp73	-.002	-.886
IQ*Texp74	.0004	.145
IQ*Texp75	.001	.645
IQ*Hdeg73	.150	1.49
IQ*Hdeg74	-.097	-1.27
IQ*Hdeg75	-.026	-.418
IQ*CollegeRating73	.026	.448
IQ*CollegeRating74	-.066	-1.13
IQ*CollegeRating75	.014	.241
	Ability	
IQ	.382*	5.53
Sex	.462	.874
	Peer Characteristics	
SDCS73	-.106	-.530
SDCS74	.164	.805
SDCS75	-.012	-.065

(cont.)

TABLE 3-16 (continued)

Variables	Coefficients	t-statistics
SDCS76	.382*	2.20
MeanCS73	-.030	-.447
MeanCS74	-.130	-1.79
MeanCS75	.167*	2.59
MeanCS76	.536*	9.88
ClassSize73	-.179	-.284
ClassSize74	1.36*	2.19
ClassSize75	.522	.763
Attend74	.331	1.57
Attend75	-.119	-.677
Schsize74	.001	.635
Schsize75	.001	.488
Schsize76	-.013*	-4.62
Ratio74	.008	.063
Ratio75	.049	.403
TitleIS74	-.005	-.873
TitleIS75	.0002	.051
TitleIS76	.016*	4.29
constant	-72.12*	-2.51

*Significant at the .05 level.

Dependent variable: $CS76 - \gamma^4 CS72$; 1976 composite achievement score on the Iowa Test of Basic Skills (ITBS) minus$(.90^4)$ 1972 composite achievement score on ITBS. $R^2 = .446$, n = 838, gamma = .90.

education (Hdeg73) were negative and insignificant but the coefficient was suspiciously large. The current instructor's nature of degree (Eddeg76) was the strongest of the four years examined; the coefficient was negative implying that possession of a baccalaureate degree in education had a deleterious impact on achievement growth. Overall, the main contributors to achievement growth were the student's ability (IQ), classroom mean and standard deviation of achievement, school size, percentage of non-white teachers, and number of enrolled Title I students. The current year class mean achievement (MeanCS76) was significantly positive. The direct and indirect effects of the first lagged year (MeanCS75) were also significantly positive but smaller than the current year effects. The standard deviation of class achievement in the current year (SDCS76) was positive implying diversity was important for seventh grade blacks. Current year's school size (Schsize76) was significantly negative while the number of Title I students enrolled in the school (TitleIS76) was significantly positive. As was true for eighth grade blacks, the indirect effects of the percentage of non-white teachers in the 1975 school (TNW75) were significantly positive.

As was the case in the previous two samples, the direct estimate of gamma, or the coefficient on CS75, was lower than the value of gamma consistent with the smallest error sum of squares (.771 versus .900). The teaching characteristics were fairly consistent across the two equations. The direct effects of experience (Texp73, Texp74, Texp75 and Texp76) were insignificant with the exception of Texp75. This variable was a significant, negative predictor of achievement.

The cumulative effects of Texp75 were also negative but not significant at the .05 level. The direct effects of level of education were insignificant as were the indirect effects. The direct effects of teacher's college rating, sex, and teaching/IQ interactions were not important predictors of achievement. The reduced form estimates showed that the indirect effects were also insignificant. The direct effects of current instructor's nature of degree (Eddeg76) were significantly negative across the equations.

In contrasting the peer group variables we observed that the direct effects of current class mean achievement (MeanCS76) were always significantly positive. The first lagged year's (MeanCS75) direct effect was negative; however, the cumulative effects were positive and significant. The direct effects of current class standard deviation (SDCS76) were positive across the two equations and the reduced form revealed that earlier effects of standard deviation were not critical to achievement growth.

The direct effects of two school-level variables, TitleIS76 and Schsize76, were consistently significant across equations. The signs on the coefficients were positive and negative, respectively. Finally, we again observed the interesting result that the cumulative impact of the percentage of non-white teachers in the first lagged year (TNW75) was significantly positive.

Summary of Results Across Samples

It was discussed in the first two chapters that a model which attempts to determine the importance of teaching characteristics in the production of student achievement should include measures of both present and past teaching resources. The possible mis-estimation of instructor's contribution due to omission of previous characteristics was one of the primary motivations for this analysis. The empirical results from including four years of teaching variables provides the first strong evidence that certain previous teaching characteristcs are not influential variables in the production function. Table (3-17) contrasts the significant coefficients across the three samples. A comparison of the direct and cumulative effects of teacher's experience and level of education across samples appears in Table (3-18).

In attempting to determine which characteristics significantly effect achievement, we can see from Table (3-17) that three variables (IQ, MeanCS75, and MeanCS76) are consistently significant across the samples. The coefficients on each instructor's undergraduate college rating and recency of degree were never significant in either the structural or reduced from equations. With few exceptions, the cumulative effects of teachers' sex (Tsex73-Tsex76), nature of degree (Eddeg73-Eddeg76), attendance (TAttend74-TAttend76), and various IQ/teacher characteristic interactions were not significant at the .05 level. The pay parameter characteristics, years of experience and level of education, were not important in the production of achievement. Overall, it seems safe to conclude that the omission of these characteristics does not seriously reduce the explanatory power of the model.

The insignificance of many lagged variables suggested a further implication could be drawn regarding the interpretation of gamma. In

TABLE 3-17

Comparison of Cumulative Effects of Significant Variables

(t-statistics in parentheses)

Teaching Characteristics

Variables	Whites	Eighth Grade Blacks	Seventh Grade Blacks
Texp75	.447 (2.65)*	.381 (1.07)	-.422 (-1.38)
Tsex74	1.47 (2.26)*	.079 (.094)	.163 (.163)
Eddeg76	--[d]	--[d]	-1.58 (-2.08)*
TAttend75	.217 (2.49)*	-.271 (-1.33)	.198 (1.20)
TNW75	.052 (1.10)	.044 (2.07)*	.041 (2.10)*
IQ*Texp75	-.003(-2.35)*	-.002 (-.907)	.001 (.645)
Ability			
IQ	.405 (9.35)*	.448 (7.27)*	.382 (5.53)*
Peer Characteristics			
SDCS73	-.371 (-2.24)*	.220 (1.06)	-.106 (-.530)
SDCS75	.367 (2.98)*	.243 (1.27)	-.012 (-.065)
SDCS76	--[d]	-.027 (-.181)	.382 (2.20)*
MeanCS75	.083 (1.74)	.016 (.239)	.167 (2.59)*
MeanCS76	.322 (7.79)*	.630 (10.98)*	.536 (9.88)*
ClassSize74	.405 (.803)	-.552 (-.816)	1.36 (2.19)*
ClassSize75	.191 (.370)	-1.68 (-2.40)*	.522 (.763)

(cont.)

TABLE 3-17 (continued)

Variables	Whites	Eighth Grade Blacks	Seventh Grade Blacks
ClassSize76	-1.70 (-3.31)*	--[d]	--[d]
Attend74	-.501 (-2.68)*	-.249 (-1.11)	.331 (1.57)
Schsize76	--[d]	-.003 (-.837)	-.013 (-4.62)*
Ratio75	.513 (2.89)*	.212 (1.39)	.049 (.403)
		Family Background	
TitleIS76[e]	--[f]	.008 (1.55)	.016 (4.29)*

[d]The direct effects were insignificant in the structural equation; thus, they were not measured in the reduced form equation (see note 12).

[e]TitleIS variables are considred family fackground measures as was described in Table (2-1). They could also be classified as peer characterisctics.

[f]These variables were not estimable for whites.

*Significant at the .05 level.

TABLE 3-18

Comparison of Direct and Cumulative Effects
Pay Parameter Characteristics

(t-statistics in parentheses)

Direct Effects[g]

Experience	Whites	Eighth Grade Blacks	Seventh Grade Blacks
Texp76	.044 (.67)	.004 (.04)	-.014 (-.20)
Texp75	.136 (2.69)*	-.057 (-.50)	-.169 (-2.42)*
Texp74	.091 (1.56)	.036 (.33)	.039 (.55)
Texp73	.028 (.59)	.167 (1.79)	-.037 (-.62)
Level of Education			
Hdeg76	-.715 (-2.03)*	.979 (1.64)	.055 (.12)
Hdeg75	.660 (1.67)	1.51 (2.34)*	.393 (.91)
Hdeg74	-.577 (-1.51)	1.19 (1.61)	-.939 (-1.83)
Hdeg73	-.569 (-1.38)	.949 (1.32)	.104 (.18)

Cumulative Effects[h]

Experience	Whites	Eighth Grade Blacks	Seventh Grade Blacks
Texp76	-.018 (-.187)	--[i]	.040 (.341)
Texp75	.447 (2.65)*	.381 (1.07)	-.422 (-1.38)
Texp74	.009 (.048)	.319 (1.01)	-.214 (-.736)
Texp73	.132 (.739)	.145 (.436)	.071 (.269)
Level of Education			
Hdeg76	-.015 (-.027)	.668 (.922)	--[i]

(cont.)

TABLE 3-18 (continued)

Level of Education	Whites	Eighth Grade Blacks	Seventh Grade Blacks
Hdeg75	-2.59 (-.641)	1.48 (.246)	3.22 (.545)
Hdeg74	1.81 (.435)	.897 (.135)	8.58 (1.20)
Hdeg73	-3.20 (-.719)	-6.71 (-.920)	-16.76 (-1.76)

[g] These coefficients are taken from equations (3-1), (3-3), and (3-5).

[h] These coefficients are taken from Tables (3-6), (3-11), and (3-16).

[i] The direct effects were insignificant in the structural equations; thus, they were not measured in the reduced form equations.

*Significant at the .05 level.

the structural equation (equation (2-17)), the coefficient on previous score (CS75) reflected genetic, environmental, and school effects which were not directly capturable. The reduced form equation (equation (2-18)) attempted to separate gamma into indirect components and attribute some of its magnitude to previous teacher, peer, and school-level inputs. Since so few lagged variables were significant, particularly in terms of the teaching variables, it can be concluded for the most part that the determinants of previous score (CS75) do not include the variables tested in this study. This conclusion implies that previous studies which utilized lagged achievement as a "control" for inputs that were not separately capturable did not seriously underestimate the total contribution of teaching characteristics as measured by experience, level of education, undergraduate college rating, nature of degree, sex, and attendance. Underlying this conclusion is the knowledge that this study represents the first attempt to explicitly model and empirically test previous input effects. Further longitudinal research is necessary to determine if the results can be replicated across different students.

Chapter 4

CONCLUSIONS AND IMPLICATIONS

The primary motivation for this analysis was to determine the effects of previous and current resources, particularly teaching resources, in the production of student achievement. Since empirical studies to date have been unable to thoroughly examine previous resource effects, this study serves twin purposes; it provides a check on the accuracy of cross-sectional analyses as well as explicitly modeling and empirically testing for previous input effects. A brief summary of the procedure and findings will be presented, followed by a section discussing the implications of this study for theory, practice, and further research.

Summary of the Procedure and Findings

In order to capture all possible effects associated with previous inputs, the model allowed for two distinct types of impacts. Previous inputs were postulated to directly impact current achievement. They were further postulated to indirectly impact current achievement through previous achievement. Previous achievement level was utilized by some researchers (Hanushek, 1971; Murnane, 1975; and Summers and Wolfe, 1977) as a "control" for previous resources that were not capturable. The theoretical model outlined in Chapter 2 divided the coefficient on previous achievement into indirect components and attempted to attribute some of its magnitude to previous teacher, peer, and school level inputs. Direct effects of current and previous inputs were observable from the structural equation (equation (2-17)). The reduced form equation (equations (2-18) and (2-18a)) permitted the estimation of the indirect effects of an input through previous achievement; it thus provided the best measure of an input's total contribution.

The results across white, and seventh and eighth grade black samples illustrated that previous and current teacher inputs, as measured by experience, level of education, recency of baccalaureate degree, nature of baccalaureate degree, baccalaureate college quality, sex, and attendance, were not critical determinants of student achievement. Various interactions of student's ability (IQ) with the above teaching characteristics also proved to be insignificant predictors of student achievement. The only consistently performing teacher characteristic was the percentage of non-white teachers in the student's 1975 school (TNW75). The coefficient on this variable was positive across all three samples and statistically significant for seventh and eighth grade black samples. Three additional inputs were consistently significant across the samples. Ability, as measured by IQ, and peer inputs, as measured by classroom mean achievement for the current and first lagged year (MeanCS75, MeanCS76), were consistently positive. With one exception, the coefficients on these variables were all statistically significant at the .10 level. These results are even more interesting in light of the fact that school differences were unimportant in explaining student achievement. As can be seen in Tables (B-4), (B-8), and (B-12) of Appendix B, the coefficients on the school dummy variables were significant only for black seventh graders. Even in this sample only 10 out

68 schools had coefficients significant at the .05 level.

Implications for Theory

The methodological construct employed to determine the effects of various inputs on student achievement was that of the production function. The production function approach as several limitations. First, there is no theory of learning to explain the acquisition and retention of knowledge from which such a function would be derivable. In industrial production it is generally assumed that the underlying relationships between inputs which guide the production process are known and reflect exogenous technological processes. This approach seems reasonable when characterizing the relationship between labor and specific types of machinery; in education the approach may have less merit since considerable choice exists in terms of both inputs and processes. While the production function methodology may seem to be more applicable to certain sectors of the economy than others, it is still a highly useful method of relating inputs to outputs. In education, however, unlike industrial production, public policies are often discussed in terms of the results of estimating educational production functions (Hanushek, 1979). While implications for policy can be made, attempts to alter behavior on the basis of estimated regression coefficients must be made with a great deal of caution. The time period and location where the data originate will circumscribe the generalizability of the empirical results.

Given the production function methodology, we still cannot ignore the problems associated with measuring a single ouput. The statistical implications of omitting non-cognitive outputs were discussed in

Chapter 2. The problem can be minimized, but not entirely ignored, by examining elementary school students. The weight on cognitive outputs in elementary school is likely to be higher than in junior and senior high schools.

A final related point concerns the belief that longitudinal studies will make improvements in the specification of the educational production process. The results of the present study regarding the significance of various teaching characteristics (see Tables (3-17) and (3-18)) are not that inconsistent with previous studies which analyzed data specific to the individual student. Hanushek (1971), Murnane (1975), and Summers and Wolfe (1977) found teacher's level of education to be an insignificant predictor of achievement. Hanushek (1971) and Murnane (1975)[1] found years of teaching experience to be unimportant while Summers and Wolfe (1977) found experience to be negatively related to the learning growth of low achievers but positively related to the learning growth of high achievers. They also found the quality of the teacher's undergraduate college to be influential, particularly for low-income students. The lack of significant interaction variables across all three samples in the present study is in direct contrast to Summers and Wolfe. Summers and Wolfe utilized sub-samples of high, middle, and low achievers while the present study interacted the teaching characteristics with ability (IQ). As was discussed in each sample's section on insignificant variables, the division of IQ into segments of low, middle,

[1]Recall (page 28) that Murnane found experience between one and three years to be significant. The marginal benefits between three and five years declined and experience beyond five years was insignificant.

high, and exceptional and subsequent interaction with teaching characteristics produced no significant results. We conclude that either sub-samples of IQ are measuring different attributes than sub-samples of achievement or that the existence of vintage and selection effects (Murnane and Phillips, 1980) may obscure the relationship between experience and achievement.

The lack of significant direct effects across most of the lagged variables suggests the exclusion of previous characteristics does not seriously underestimate the total contribution of instruction as measured by experience, level of education, quality of baccalaureate college, nature of baccalaureate degree, sex, and attendance. Further, these same characteristics were not critical determinants of gamma, or the coefficient on lagged composite score. Previous studies which utilized lagged achievement as a "control" for inputs that were not separately capturable were probably not understating the effect of the commonly measured teaching characteristics. Given the huge data requirements inherent to longitudinal analyses the conclusion that lagged characteristics have little or no lasting impact suggests extensive data collection of these attributes may ultimately be unproductive.

Implications for Practice

A knowledge of the technological relationship between educational outputs and inputs can be utilized to suggest the state of efficiency in resource allocation. Once the educational production function and the prices of the educational inputs are known, the minimum cost combinations of inputs producing the output can be determined. In order to minimize costs subject to a given output (or maximize output subject to given costs) inputs must be employed in such a way so that the marginal rate of technical substitution equals the input price ratio. Equivalently, the marginal product to price ratios must be equal across inputs. These equalities determine economic efficiency.[2]

Three broad categories - family, school and peer group characteristics - were identified as potentially important inputs in the educational production function. In determining economic efficiency, however, the most relevant inputs are the school and teaching characteristics. In the case of the family inputs, it is not really possible to meaningfully determine the marginal product to price ratios. The "true" family inputs are not sold in the market. For example, if family income is used as a proxy for family background, income differences between two families may or may not accurately reflect the characteristics which have an impact on achievement.

Schools, on the other hand, purchase teacher characteristics such as possession of a graduate degree and/or years of experience. While this does not imply that teacher "quality" is totally captured by these two attributes, the fact remains that school administrators do not explicitly buy "quality" but instead purchase a bundle of readily identifiable characteristics. Presumably they purchase experience and degrees because they have a strong, positive impact on achievement (Hanushek, 1972:27-32). Alternatively they do so because teacher's unions have successfully negotiated these measures in lieu of less objective estimates of quality. The marginal products of the two

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[2]See Ferguson (1972) or Henderson and Quandt (1971) for a complete discussion.

attributes can be determined directly from the production function. Due to the instability of the coefficients on level of education (Hdeg73 - Hdeg76) we will calculate the marginal benefits and costs of teacher experience only. An examination of the salary structure from the metropolitan area considered in this study will yield the price of experience. The marginal benefits and marginal costs can then be compared to suggest the state of efficiency in terms of hiring. In applying the efficiency criterion it will become clear that a resource which has no positive impact on achievement can be reduced or eliminated. The resulting cost savings can then be allocated to resources which do benefit achievement.

Two caveats are necessary before specifically addressing efficiency considerations. First, efficiency implications are based upon seventh or eighth grade students enrolled in single school system. The data utilized to estimate equations (2-17) and (2-18a) originated from a large central city in the midwestern United States. Sample selectivity bias may be present as the following stylized salary function suggests:

Let

$P = P(T) = T(E, D, Z)$

where: T = teaching ability

E = teaching experience

D = advanced degrees

Z = motivation or drive, readily identified by hiring officials but not observed by researchers

P = salary.

If one assumes jobs in the suburbs are more desirable than jobs in the central city, those teachers retained in the central city may have high E and D but unusually low Z. Murnane and Phillips (1980) argue that the existence of selection effects, defined as differences between the average abilities of teachers of a given experience level who choose to remain classroom teachers and those who choose to leave classroom teaching (or transfer to "good" suburban schools), will understate the estimated relationship between experience and student achievement in a cross-sectional sample. They also demonstrate that when vintage effects, or differences in the average abilities of teachers hired at different points in time, are explicitly considered the effects of experience are more pronounced. Thus, in calculating the marginal product to price ratios we must acknowledge that although experience was not a critical explanatory variable in this particular study, selection and vintage effects may exist and bias downward the experience/achievement relationship. Becker (1952) has shown that there are patterns of selectivity in teachers' movement from job to job, but he did not determine if the selection process had anything to do with teaching quality.

The second caveat concerns classroom size. Implicit in the following section on cost estimates is the assumption that classroom size is constant. Although the role of classroom size has been thoroughly researched, no real consensus regarding the sign and significance of its coefficient has been reached. In a review of past studies Glass and Smith (1978) found that average student achievement was increased when classroom size was less than 20. The gains from reducing classroom size in the 20 to 40 range were slight. In Chapter 3 we noted that classroom size was generally not a critical explanatory variable.

As Murnane (1980) argues, classroom size is best viewed as a secondary resource that affects achievement through its influence on student and teacher behavior (e.g., the costs of large classroom size may be borne primarily by children with learning problems. Children with learning problems may be absent when achievement tests are administered and hence are excluded from the data samples).

Marginal Benefits and Marginal Cost Estimates for Teacher Experience

In determining the relationship between marginal benefits and marginal costs of teachers' experience, we were hampered by the lack of statistically significant coefficients on the variables. As one approach to the problem we took the reduced form coefficients on teacher experience, regardless of significance level, and calculated each instructor's marginal benefit across the entire class by assuming an additional year of education raises wages by four percent (Kalachek and Raines, 1975). Since the achievement scores are reported in grade-equivalent units (see page 28), 10 points on the achievement scale equals one year of education. The reduced form coefficient multiplied by the wage elasticity equals the permanent percentage increase in wages due to a unit increment in the input. Translating that percentage increase in hourly wages into annual, dollar terms, multiplying by the average classroom size, and computing the present value will yield the present value of the benefits of an incremental increase in an input (e.g., one additional year of teaching experience). The present value of the marginal benefits were then compared to the marginal cost of the input to determine if the conditions necessary for economic efficiency were being met.

To illustrate this approach consider the following equation from the white sample:

$$(4\text{-}1)\quad CS76 - \gamma^4 CS72 = .132Texp73 + .009Texp74 + .447Texp75 - .018Texp76 - .0006Texp73^2 - .003Texp74^2 - .004Texp75^2 + .0003Texp76^2 + \text{remainder of the equation} .$$

For the input Texp73, the contribution of an additional year of experience is given by the partial derivative of $CS76 - \gamma^4 CS72$ with respect to Texp73:

$$(4\text{-}2)\quad \frac{\partial(CS76 - \gamma^4 CS72)}{\partial Texp73} = .132 - .0012Texp73 .$$

To examine the strongest possible case for Texp73, let Texp73 = 1.

$$(4\text{-}3)\quad \frac{\partial(CS76 - \gamma^4 CS72)(yrs)}{\partial Texp73} = .132 - .0012 = .01308 .$$

If we assume a constant four percent wage gain per year of education, a mean wage of $10 per hour, and 2,000 hours worked per year, the total classroom increment (TCI) for Texp73 for a class size of 29 will equal $303.45. Utilizing the present value (PV) formulation of:

$$(4\text{-}4)\quad PV = \frac{TCI}{r}\frac{1}{(1+r)^n}$$

where: TCI = total classroom increment

r = discount rate (assumed = .1)

n = number of years until earnings start (assumed = 4 since most students are eighth graders)

we can calculate the present value of the benefits due to an additional year of teaching experience.

Table (4-1) reports the reduced form coefficients for teachers'

TABLE 4-1

Reduced Form Equation Teacher Experience Coefficients Total Direct and Indirect Effects[a]

Variables	Whites	Eighth Grade Blacks	Seventh Grade Blacks
Texp73	.132	.145	.071
$Texp73^2$	-.0006	-.002	.004
Texp74	.009	.319	-.214
$Texp74^2$	-.003	-.003	.004
Texp75	.447*	.381	-.422
$Texp75^2$	-.004	-.002	.006*
Texp76	-.018	--[b]	.040
$Texp76^2$	.0003	--[b]	-.001

*Significant at the .05 level.

[a]These coefficients are taken from Tables (3-6), (3-11), and (3-16).

[b]The direct effects were highly insignificant in the structural equation; thus, they were not measured in the reduced form equation (see note 12, Chapter 3).

experience. Table (4-2) reports the present value of the marginal benefits of experience and also reports, by examining the appropriate year's salary scale, the marginal cost of an increment of experience. In calculating the marginal benefits a negative coefficient on the linear experience term was assumed to equal zero. Several additional points regarding the calculations are worth noting. Given a negative sign on the squared experience term, the marginal benefits become negative when the number of years' experience multiplied by the coefficient on squared experience exceeds the coefficient on the linear term. The estimated coefficients, however, are presumably underestimates since the contribution of experience to students beyond the eighth grade is not measurable. This latter point is particularly true for more recent inputs (e.g., Texp76 has only the current year to make a contribution). Ideally we would like to measure the total contribution of an input when students have completed their last year of education.

In most benefit/cost calculations, benefits are found to be either consistently greater than or less than costs. Although Table (4-2) is based on a number of assumptions, we can see that there is no consistent relationship between marginal benefits and marginal costs. The erratic pattern is probably a reflection of the fact that a majority of the reduced form coefficients were statistically insignificant.

Implications for Future Research

Given the unique nature of the longitudinal data utilized in this study, several alternative approaches to study the effects of

TABLE 4-2

A Comparison of the Marginal Benefits and Costs of Teachers' Experience ($Texp_{71} = 1$)

Present Value of the Marginal Benefits[a]

Variables	Whites	Eighth Grade Blacks	Seventh Grade Blacks
Texp73	$2,078.29	$2,240.77	$1,212.17
Texp74	47.67	4,802.67	122.75
Texp75	7,217.16	5,991.28	184.12
Texp76	9.52	--[b]	583.07

Marginal Costs of Experience[c]

1973	$360
1974	360
1975	400
1976	486

[a]The marginal benefit calculations are based on the average class size of each sample for the year in question.

[b]The direct effects were not measured in the reduced form; thus, the present value could not be calculated.

[c]Given a baccalaureate degree, the marginal costs were generated by examining salary increments from one to two years of experience.

teachers on students are suggested. The data could be utilized to follow teachers (as opposed to students) over time. This approach would have the benefit of reducing measurement error because classroom averages could be used as the measures of achievement. School administrators would also be able to assess their staffs over a long period of time. Examination of one year's worth of data would create incentives for teachers to introduce numerous kinds of year-specific explanations for performance. The data could also be utilized to locate specific teachers who were effective at producing achievement gains. Comparison of effective and ineffective teachers through individual observation could point the way toward collection of more relevant variables and also help develop theories of instruction.

Appendix A

DATA PROCEDURES

The two unusually large data bases which are being utilized for this study required a great deal of attention before statistical procedures could be applied. Access to the student data base was made possible by the Board of Education of a large midwestern city. The Board supplied the original data base which contained 313,456 student records covering the years 1968 to 1976 and grades three through eight. The teacher data base was provided by the state where the city is located. The original file contained information on all certified teachers in the state for the years 1968 to 1976. Because this particular study involves only one city, the teacher base presently being utilized consists of 21,983 teachers.

The various procedures and steps which were necessary to merge the two data bases are explained below. It was felt a careful documentation of procedures was essential for two reasons. First, the conclusions reached at the end of an empirical study are often a result of logical and necessary procedures applied during the course of data management. Second, careful documentation is essential if the data are to be replicated. The ability to replicate empirical studies is a highly desirable feature of not only economic research but research across all disciplines. It is hoped a careful documentation of procedures will not only make replication possible, but, at the same time, encourage it.

Step I - Elimination of Years

The first three years, 1968 through 1970, of both data bases were eliminated. This procedure was necessary because the achievement tests were not administered consecutively. Some schools administered the Iowa Test of Basic Skills at the beginning of the school term while others administered the test at the end. A May achievement test implied assessing the contribution of the current year's instructor. A September test implied an evaluation of the previous year's instructor. The mix of the two situations in one year would have complicated the analysis considerably.

The frequency of students in these early years varied widely as the following table shows:

TABLE A-1

Frequency of Students by Year

Year	Number of Students
1968	40,798
1969	18,928
1970	18,820
1971	20,806
1972	39,484
1973	43,083
1974	41,989
1975	40,061
1976	49,487

The sudden drop in magnitude of students from 40,798 in 1968 to 18,928 in 1969 suggested problems with the data collection.

A further serious problem existed with duplicate student identification numbers. A student number was called a duplicate when more than one record contained the same identifier number for a given year. This situation arose for one of three reasons: (1) the records actually were identical but simply keypunched twice; (2) a student took the achievement test twice in the same year, thus resulting in two records; or (3) the same identifier number was assigned to two entirely different students. The large frequency of duplicates in the early three years, 41,585 out of 78,546, was a further justification for eliminating those years from the analysis. Aside from the above specific reasons, the Board indicated that, in general, accurate, systematic data management really did not begin until 1971.

Step II - Teacher Name Comparisons

The merging of the two data bases depended entirely upon matching the teacher name, school and year across the student and teacher files. The teacher name in the student file comprised an 11-column field as opposed to the 22-column field of the teacher file. The teacher names, school, and year were listed out for both files and side-by-side comparisons made. The spelling was matched to the first five letters and name reversals were corrected. Blank spaces were filled in when it was possible to assign a name. The following example demonstrates the procedure:[1]

Student File				Teacher File			
teacher name	school	year		teacher name	school	year
D-e-J-h-	1111	75		Doe-John	1111	75

The teacher file was the more highly accurate of the two fields and most changes were made to reflect this fact. There were 14,430 corrections made during this step, resulting in 191,514 records in which student and teacher data were merged.

Step III - School Number Comparisons

The four-digit school number did not always match between the two files for the same teacher in a given year. The outline of the general problem was as follows: The teacher file was constructed in September of each year, primarily for payroll purposes. The student file was constructed in the spring when the achievement tests were administered. Even when the teacher name and year were identical on the two files, the school number did not always match. Early reasoning suggested that a teacher could be transferred to a different school after the teacher file was constructed. He or she would not appear in that school until the following fall - or perhaps not even then if they only stayed in the transferred school one year. In the more normal case, where the instructor stayed in the transferred school for a period

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[1]The names utilized throughout this appendix were pseudonyms. The school numbers are also fictitious.

longer than one year, the student and teacher files eventually agreed. The first set of changes were thus made on the teacher file. This was a problem of considerable importance since additional school-level data from separate sources were to be merged in on the basis of school number at a later time.[2]

School numbers did not always match because the school number in the student file was invalid. These cases were separated from the main file and attempts were made to ascertain the proper school. The first set of corrections, with the exception of obvious keypunch errors, invalid school numbers, and situations where a teacher's entire six-year career was in one school but off in the middle year of the student file, were thus made by altering the school number in the teacher file.

Upon receipt of room attendance figures for each school it was discovered that some of the above changes were incorrect. A second set of corrections became necessary. The reports reflected March classroom attendance counts and also listed the teacher name, grade, year, and room number. This information provided a check to ascertain if a transfer had occcurred. The following cateogires illustrate the type of situations encountered.

[2]A simple example helps to clarify the problem. One school-level variable subsequently merged with the student and teacher data was racial composition. Instructuor Joseph Lewis appeared in the student file in school 7280 whereas the teacher file indicated he was in school 4350. If Mr. Lewis was transferred in late September merging in school 4350 racial composition would be incorrect as the students he taught were actually in 7280.

Teacher Transfers

	Year	Student File	Teacher File
Link, June	1974	1111	9999

The room attendance reports showed Ms. Link was in 1111 and she was further listed in 1111 for the 1975 and 1976 teacher files. Cases similar to the above clearly appeared to be transfers and the teacher file was changed to 1111.

The room attendance reports were recorded in early March while the achievement tests were administered in May. Thus, the minimum amount of time the teacher was in a particular room is three months. The full impact of a teacher's effectiveness might not be seen during such a short period. It thus became necessary to assume that a large majority of the transfers took place in the early fall, placing the teacher in the room for practically the entire school term. Conversations with various individuals at the Board of Education indicated this was not an unrealistic assumption. The two main reasons for teacher transfers, class size needs and desegregation ruling, operate almost exclusively in September. In any event, the teacher was assumed to be in the room long enough for the full effects to be capturable.

One-Year Teachers

In most of the cases the teacher appeared in the transferred school in the following year's teacher file. Even if the teacher only appeared in the system for one year out of a possible six, the school change was still made on the teacher file if the room attendance reports and the student file agreed. If the room attendance reports indicated the person was not in that school, no school change was made and the case failed to merge.

Keypunch Errors

The room attendance reports also made keypunch errors more obvious and the teacher or student file was changed depending on the teacher's placement in the reports. For example:

	Year	Student File	Teacher File	Room Attendance Reports
Walker, Evelyn	1975	1211	1121	1121

In this case the student file was changed to 1121.

Invalid School Numbers

A similar procedure was followed for invalid school numbers. The school change was made to reflect the teacher's placement in the room attendance reports. It became clear during this particular step that many student records with invalid school numbers had been duplicated by the original keypunchers of the data.

	Year	Student File	Teacher File	Room Attendance Reports
Rule, Claudia	1974	0000	1950	1950

Ms. Rule already had a class in school 1950 with the same number of students as she had in school 0000. Changing the 0000 school to 1950 would have given her twice as large a class as she actually had. The 0000 school number was thus changed to 9999 so it would not merge.

Schools with Branches

Several of the schools in the system had branches and were identified by a separate school number. The student file often did not differentiate between the main school and its branch. A teacher in school 1450 may actually have taught in the branch school, 1452. This situation would not have mattered except for the fact that the additional school-level data were aggregated over some but not all branches. If the additional data were aggregated (i.e., school 1450's racial composition was calculated by including students from the branch) a school number change was unnecessary. If the branch data were calculated separately, the school number in the student file was changed to reflect placement in the room attendance reports.

Step IV - "Blank" Teacher Names

No teacher names were associated with the records of 4,563 students. Due to the possible biases inherent in this situation (poor teachers deliberately leaving the forms blank) a special effort was made to find the correct teacher. The room attendance reports were crucial to this task. The student file contained school, grade, and room number variables so the "blanks" were sorted on these criteria for every year. Using the room attendance reports virtually 99 percent of the "blanks" that had room numbers were identified and the correct teacher name inserted. The remaining "blanks" could not be identified unless a situation such as the following occurred. The classroom sorts of the student file produced two full classrooms. If the "blanks" sort also produced a full classroom and only three teachers existed in the school for that grade, it was assumed the "blanks" were associated with the third teacher not in the sorted classroom file.

Correct identification was made for 2,870 "blanks." The filled-in teacher name was then checked against the teacher file for spelling and school location. During this procedure several types of situations arose.

Substitutes

It became apparent that several classrooms had substitutes not in the teacher file (instructors not certified for that year). John Doe was listed in the student file and as a temporary substitute in the room attendance reports. He never appeared in the teacher file; thus, it would have been impossible for his students to merge successfully.

XXXX Codes

The special four-digit school code, XXXX, represented teachers who were on professional leave of absence. One teacher with this classification actually had a classroom according to the room attendance reports. It was thus assumed she had planned to be on leave in the fall but was called back or changed her mind.

Branch Schools

The same procedure was followed as in Step III on page 169. Fortunately, all the particular branch schools in question were aggregated over their main schools and the room attendance reports were only necessary for consistency.

Transfers

As in previous school number problems (see Step III) a small number of the filled-in blank school numbers did not match across the two files. Again using the room attendance reports as confirmation, the teacher file was changed to match the student file.

	Year	Student File	Teacher File	Room Attendance Reports
Martin, Maude	1975	5555	1111	5555

Ms. Martin was also in the 1976 teacher file in school 5555 so this case, and other like cases, were assumed to be transfers.

Step V - Duplicate Teacher Names

A duplicate teacher existed when two teachers had the same name and were in the same school for the same year. Since the merge process was on the basis of the first five letters of teacher name, school and year, names like Brown would not merge properly. The following case is an example from the student file:

		School	Grade	Room Number
Brown	1971	2100	4	218
Brown	1971	2100	8	304

Merging on the first five letters, school, and year might have placed the wrong students and teachers together. The teacher file was sorted on the first five letters of the name, school, and year and a counter attached to check for duplicates. The student file was sorted similarly and "eyeballed" for duplicates. Using the room attendance reports to identify the first name, the merge than took place on the entire 11-character field of teacher name. In the above example, extending Brown to include the first names made the name unique and the merging process culminated properly. Only in one case did the 11-character field contain a duplicate and the "blank" between the first and last name was removed to make it unique. (Washington is not unique up to 11 characters unless the space is compressed between the first and last name).

If the room attendance reports showed a different teacher than was present on the student file, the year was changed to "99" to make a non-merge case.

	School	Year	Grade	Room Number
Bond	1111	1973	3	119
Bond	1111	1973	3	125

The room attendance reports showed Room 119 was occupied by Mary Sims whereas Room 125 was occupied by Joyce Bond. The student records associated with Room 119 were changed so they would not merge. If the teacher administering the achievement test did not appear in the March room attendance reports, one could not be certain the teacher was in the room for even three months. It was thus felt forcing the case to not merge was the most desirable option. These cases were later checked for two-person rooms, a category which will be further explained below.

Merge Information

The whole process began with 313,456 student records covering the years 1968 through 1970. The first three years were eliminated (78,546) and "blanks" (4,563) and duplicate teacher names (13,320) were handled on separate files. Additional records (3,770) were eliminated if the four-digit school number exceeded 8999. Aside from these schools being either private or church-related, the teacher name field was the school name displaced by one column. This fact cast doubt on the nature of the records so they were removed. Thus, 213,257 records were left to correct names and schools. Of these 191,514 student records merged successfully; 21,743 failed to merge based on the criteria of five-letter name, school and year.

These 21,743 non-merged records fell into roughly seven categories.

Non-Matching Years

The largest category was comprised of cases where the student file teacher did not appear in the teacher file until the subsequent year (i.e., the teacher was in both the room attendance reports and student file for 1974 but not in the teacher file until 1975). Since school effects are measured by the characteristics of the teacher in the given year, no attempt was made to backdate teacher records. Years of education, experience, and salary in a subsequent year would not reflect the current year accurately so these cases remained without teacher data.

Teachers on Leave

The second group consisted of teachers who were listed as on professional leave in the teacher file but appeared in the room attendance reports and/or the student file. Since it was often difficult to ascertain how long the teacher was in the classroom or the form of their compensation, these records remained without teacher data.

Name Corrections (continued)

This category consisted of name corrections which were missed in the first phase of the process due to human error.

School Corrections (continued)

The fourth group consisted of school corrections not made in the first or second phase. Transfers were again assumed to occur in the early fall.

Married Teachers

Many teachers had been either married or divorced in the six year period under consideration. The teacher file often did not reflect their current status; that is, their maiden name appeared sometimes and at other time their married name appeared. As long as the teacher identification numbers were identical the name was changed to reflect their status in the room attendance reports and student file.

Substitutes

The sixth category was comprised of students whose instructors never appeared in the teacher file at all and thus were not certified personnel.

Two-Teacher Rooms

A number of students had one instructor from approximately September to March (appeared in the teacher file and room attendance reports) and another instructor from March to May (signed the achievement tests). The teacher from September to March became the teacher of record but the cases were flagged for identification of this special occurrence.

Applying the changes necessary for the above categories yielded 9,429 additional records in which student and teacher data were merged. The unmerges were thus reduced from 21,743 to 12,314.

Blanks and duplicates were combined and merged on the criteria of eleven-letter teacher name, school and year. Of these 17,883 records, 14,874 merged successfully. Included in the 3,009 non-merges were the "forced non-mergers" (the year was changed to 99). The year was then changed back for those classrooms which had two teachers. The teacher from September to March became the teacher of record and again the record was flagged to identify this exceptional case. There were 175 records in the two-teacher room category, leaving 2,834 blanks and duplicates not associated with teacher file data.

A summary on merge information indicates the following:

215,992 merged records

12,314 unmerged records

2,834 unmerged blanks and duplicates

231,140

The unmerged records were "merged" so they would again be part of the working file, yet blanks appeared following the usual teacher information. This procedure was necessary so that all student records had a logical record length of 263 characters.

Step VI - Addition of School Level Data

Data which were obtained from other sources but relevant to the working merged student/teacher file were added to make the logical record length 296 characters. Unlike the earlier data which were collected at the individual level, the seven added variables were aggregated at the school level. The variables were:

1. Regular Grades - the total enrollment of the school,
2. Title I Students Served
3. Percentage of Student Attendance
4. Percentage of Non-White Students
5. Percentage of Teacher Attendance
6. Percentage of Non-White Teachers
7. Pupil/Regular Classroom Ratio.

These data were merged by school number to all student records for the fiscal years 1974 through 1976.

Step VII - Addition of Gourman Data

Two variables were added to the working file in order to test for a possible relationship between the teacher's undergraduate and graduate training and student achievement. The institution where the teacher received his or her degree and any graduate degrees was already present on the working file. The two added variables were Gourman ratings of the Baccalaureate Institution and the Highest Degree Institution. The Gourman ratings were based on the undergraduate programs of nearly all colleges and universities in the United States. The areas rated included: (1) individual departments, (2) administration, (3) faculty (including research), (4) student services, and (5) general areas such as facilities and alumni support. The actual rating was thus a simple average of these five areas (Gourman, 1967). With the addition of the two Gourman variables the logical record length equaled 302 characters.

Step VIII - Duplicate Student Numbers

It was previously mentioned that one of the justifications for eliminating data from 1968 through 1970 revolved around the large number of duplicated student numbers. Duplicate student numbers, also present in the 1971 through 1976 data, were handled in the following manner:

Identical Number-Different Student

Each time a student number appeared more than once in the same year, all the years (1968-1976) associated with that number were printed and the birth dates compared. The record which had a birth date not matching the pattern of the other years was eliminated.

Student Number	Year	Birth Date
000200	1968	3/57
000200	1971	3/57
000200	1971	5/58

In the above case the record with birth date 5/58 was deleted. A majority of the cases fell into this category and were thus easy to disentangle. If the birth dates were identical and the grades different, the record "out-of-step" on grade progression was deleted.

Student Number	Year	Grade
001772	1972	6
001772	1973	7
001772	1973	8

Here the record associated with grade 8 was eliminated. Implicitly it was therefore assumed students were not retrained or advanced in grades.

Identical Number - Identical Student

The printing of the entire record, including test scores, showed certain records were not exact duplicates of each other. One record of the two was then deleted.

Identical Number - Identical Student - Different Scores

A small number of records with the same student number appeared to be the same individual who had been retested on his or her achievement. Retests were supposed to occur when a studnet performed exceptionally above or below his projected work level. In practice, retests occurred infrequently and since scores were not widely disparate, a random record was dropped. The number of deletions due to the above three categories totaled 3,239 leaving 227,901 records. Of the 313,456 total possible records, 72 percent thus remained and constituted the working "merged" file.

Step IX - Creation of Classroom Variables

Student peer group characteristics, so important in previous research (Coleman et al., 1966; Murnane, 1975; Winkler, 1977; and Summers and Wolfe, 1977), were created from variables present on the original student file. All students having a valid teacher (the teacher identification number was not missing) were sorted by teacher identification number and year to obtain unique classrooms. If the teacher identification number was missing, the students were sorted by year, school and room number to again obtain a unique classroom. While the goal was to calculate classmate characteristics over the widest range of possible students, several words of caution are necessary. If a student was absent the day the achievement tests were given, he or she would not appear in the student file for that particular year. If low achievers are systematically absent, variables such as class mean achievement will be over-estimates of the true classroom mean. To determine the extent of absences a random check was made comparing the room attendance counts to the class size of the student file. In a majority of the classes the student file classroom counts deviated only two or three students from the room attendance figures. Although the closeness of the two figures was encouraging, the comparison was still rather crude and the possibilities for bias remain strong.

The classmate characteristics created were the following:

1. Mean achievement of the classroom (Iowa Test of Basic Skills)
2. Standard deviation of classroom achievement
3. Variance of classroom achievement
4. Skewness of classroom achievement
5. Mean IQ (Stanford-Binet Intelligence Test)
6. Standard deviation classroom IQ
7. Variance of classroom IQ
8. Skewness of classroom IQ
9. Classroom size

The only students for which classmate characteristics could not be calculated were those with both an invalid teacher identifier and an invalid room number. In these cases a unique classroom assignment was impossible. Fortunately, only 1,468 students out of the possible 227,901, or .6 percent, fell into this category.

Step X - Addition of Racial Data

The lack of good family background variables made the acquisition of racial data on the student especially important. The Board of Education provided racial information on students who had been enrolled in the city school system (elementary, junior and senior) as of September 1976. The students utilized in this study, however, covered the years 1971 to 1976. Students in the seventh or eighth grades of the early years would most likely not be in the system in September of 1976. These particular students would not have racial data associated with their records.

The racial data were merged with the working file by student number. The problem of duplicate student numbers in the racial data again arose. If a student number appeared twice and had a different race, the birth dates were printed for comparison purposes. Birth dates were printed off the working file to assure the "right" race would be merged to the "right" person. In effect, for duplicate student numbers, the merge took place on the basis of student number and birth date. Racial data were thus added to 139,435 students of 61 percent of the total "merged" sample.

Step XI - Middle and Special Schools Deleted

Assessment of teacher effectiveness is complicated considerably when a student has more than one teacher over the course of the school year. Middle schools, where the student has a different teacher for each subject, typify this situation most clearly. Students who attended middle schools were thus omitted from the analysis. Problem students assigned to special schools were also omitted since the characteristics of these students would differ radically from the main population. The number of students deleted due to their attendance in a middle or special school totaled 12,015.

Longitudinal History

One of the final steps in the construction of a working file involved building a longitudinal history for each student. The student identification number, sex, birth date, and race were placed at the front of the record. These constant variables were followed by the six potential years of test data, teacher data, school-level data, Gourman data, and classmate data. This procedure demonstrated that there were 91,595 unique students, 55 percent with racial data, covering the years 1971 to 1976 and grades three through eight.

The operational model outlined in Chapter Two requires students to be in the merged file consecutive years. A decision was thus made to limit the statistical analysis to those students who were present in the merged file either five or six consecutive years. The lack of good family background data further required the use of only those records where racial data were available. The maximum sample was thus composed of 6,605 students, or 13 percent of the total number of unique students with racial data.

Careful examination of this percentage demonstrates it is not as small as it first appears. In order to meet the five or six consecutive year stipulation, a student would have to have been in the third or fourth grade in either 1971 or 1972. Of the 91,595 unique students, 21,117 (or 23 percent) were in the third or fourth grades for the relevant grades for the relevant years. Requiring racial data reduced the maximum potential sample from 21,117 to 11,842. Since 6,605 pupils with racial data were actually present five or six consecutive years, 31 percent of the total potential sample or 55 percent of the total potential racial sample was represented.

Appendix B

FREQUENCIES, CORRELATIONS, AND SELECTED REGRESSIONS

TABLE B-1

White Sample - Years of Teacher Experience

Years of Experience	1976 Teacher	Percent	1975 Teacher	Percent	1974 Teacher	Percent	1973 Teacher	Percent
1	19	1.6	34	2.9	16	1.3	50	4.2
2	--		33	2.8	42	3.5	104	8.9
3	7	.60	28	2.3	103	8.8	67	5.7
4	52	4.4	71	6.0	37	3.1	101	8.6
5	70	5.9	55	4.7	44	3.7	59	5.0
6	46	3.9	39	3.3	70	5.9	49	4.1
7	37	3.1	42	3.5	104	8.9	68	5.8
8	41	3.5	62	5.3	88	7.5	45	3.8
9	70	5.9	67	5.7	19	1.6	29	2.4
10	61	5.2	55	4.7	27	2.3	50	4.2
11	49	4.1	38	3.2	8	.68	6	.51
12	36	3.0	30	2.5	3	.25	1	.08
13	24	2.0	11	.94	23	1.9	16	1.3
14	25	2.1	50	4.2	24	2.0	25	2.1
15	66	5.6	27	2.3	60	5.1	--	--
16	33	2.8	29	2.4	--	--	25	2.1
17	22	1.8	15	1.2	25	2.1	29	2.4
18	55	4.7	24	2.0	9	.77	12	1.0
19	29	2.4	2	.17	2	.17	25	2.1

TABLE B-1 (Continued)

Years of Experience	1976 Teacher	Percent	1975 Teacher	Percent	1974 Teacher	Percent	1973 Teacher	Percent
20	--	--	40	3.4	22	1.8	18	1.5
21	32	2.7	54	4.6	19	1.6	32	2.7
22	21	1.7	6	.51	53	4.5	41	3.5
23	27	2.3	93	7.9	25	2.1	17	1.4
24	55	4.7	13	1.1	62	5.3	22	1.8
25	64	5.4	12	1.0	21	1.7	9	.77
26	25	2.1	12	1.0	20	1.7	22	1.8
27	15	1.2	3	.25	9	.77	12	1.0
28	11	.94	31	2.6	13	1.1	21	1.7
29	39	3.3	10	.85	7	.60	10	.85
30	20	1.7	5	.42	15	1.2	1	.08
31	23	1.9	13	1.1	--	--	47	4.0
32	6	.51	1	.08	87	7.4	--	--
33	--	--	47	4.0	15	1.2	60	5.1
34	15	1.2	18	1.5	39	3.3	--	--
35	20	1.7	12	1.0	--	--	24	2.0
36	3	.25	7	.60	13	1.1	6	.51
37	25	2.1	5	.42	22	1.8	11	.94
38	--	--	28	2.3	--	--	5	.42
39	18	1.5	17	1.4	1	.08	7	.60
40	--	--	--	--	2	.17	7	.60

TABLE B-1 (Continued)

Years of Experience	1976 Teacher	Percent	1975 Teacher	Percent	1974 Teacher	Percent	1973 Teacher	Percent
41	--	--	5	.42	5	.42	12	1.02
42	6	.51	--	--	2	.17	--	--
43	--	--	--	--	11	.94	6	.51
44	--	--	16	1.3	--	--	--	--
45	--	--	--	--	--	--	--	--
46	--	--	--	--	--	--	--	--
47	--	--	7	.60	--	--	16	1.3

TABLE B-2

White Sample - Level of Education

1976 Teacher	Frequency	Percent
Baccalaureate Degree	733	62.81
Master's, Education Specialist, or Doctor's Degree	434	37.18

1975 Teacher	Frequency	Percent
Baccalaureate Degree	722	61.86
Master's, Education Specialist, or Doctor's Degree	445	38.13

1974 Teacher	Frequency	Percent
Baccalaureate Degree	782	67.00
Master's, Education Specialist, or Doctor's Degree	385	32.99

1973 Teacher	Frequency	Percent
Baccalaureate Degree	820	70.26
Master's, Education Specialist, or Doctor's Degree	347	29.73

TABLE B-3

White Sample - Correlations >.7

CS72-IQ .716	CS72-CS75 .876	Mean CS73 - Mean CS74 .776
CS73-IQ .715	CS73-CS75 .910	Mean CS73 - Mean CS75 .718
CS74-IQ .728	CS74-CS75 .939	Mean CS74 - Mean CS75 .840
CS75-IQ .747	CS72-CS74 .888	Mean CS74 - Mean CS76 .782
CS76-IQ .734	CS73-CS74 .924	Mean CS75 - Mean CS76 .836
CS72-CS76 .853	CS72-CS73 .908	Schsize 74 - Schsize 75 .857
CS73-CS76 .886	Attend 74 - Attend 75 .784	Schsize 74 - Schsize 76 .779
CS74-CS76 .911	Attend 74 - Attend 76 .712	Schsize 75 - Schsize 76 .914
CS75-CS76 .934	Attend 75 - Attend 76 .778	Tnw75 - Tnw76 .799
Recency 76 - Texp 76 .831	Title75 - Titlels74 .805	Title75 - Title76 .758
Recency 75 - Texp 75 .870	Title74 - Titlels75 .759	Title73 - Titles74 .764
Recency 74 - Texp 74 .890	Title75 - Titlels75 .992	Title74 - Titles74 .957
Recency 73 - Texp 73 .820	Titlels74 - Titlels75 .814	
Title73 - Title74 .796	Title75 - Titlels76 .729	
Title74 - Title75 .784	Title76 - Titlels76 .978	

TABLE B-4

White Sample - Structural Equation Estimates with School 76 as a Dummy Variable

Variables		Coefficients	t-Statistics
CS75		.837	35.70
IQ		.146	3.24
School 76[a]		--	--
Sex		.294	.93
Texp 76		.119	.72
$Texp\ 76^2$		.001	.44
Texp 75		.268	2.05
$Texp\ 75^2$		-.003	-2.12
Texp 74		-.027	- .19
$Texp\ 74^2$		-.002	-1.63
Texp 73		.029	.21
$Texp\ 73^2$		.001	.66
HDeg 76	1 if MA, Ed. Spec., or Ph.D.	-3.80	-1.23
HDeg 75		-3.99	-1.26
HDeg 74		1.05	.33
HDeg 73		- .532	- .15
College Rating 76	1 ≥ 300[b]	- .442	- .14
College Rating 75		-1.65	- .53
College Rating 74		-2.58	- .80
College Rating 73		-2.29	- .75
Eddeg 76	1 if Degree in Education	- .691	-1.13
Eddeg 75		- .647	-1.01
Eddeg 74		- .273	.48
Eddeg 73		- .265	- .56
MeanCS 76		.171	4.76
MeanCS 75		.030	.80
MeanCS 74		- .023	- .51
MeanCS 73		.028	.76
SDCS 76		- .052	- .66
SDCS 75		.055	.49
SDCS 74		- .115	- .85
SDCS 73		- .196	-1.43
Class Size 76	1 if ≥ 30	- .783	-1.45
Class Size 75		- .269	- .53
Class Size 74		- .319	- .74
Class Size 73		.616	1.31
Attend 75		.583	1.90
Attend 74		- .455	-2.02
TAttend 75		.126	.74
TAttend 74		.003	.03
Tnw 75		.076	.98
Schsize 75		- .0002	- .05
Schsize 74		.003	1.00

TABLE B-4 (Continued)

Variables	Coefficients	t-Statistics
Pupil/Teacher Ratio 75	.154	.65
Pupil/Teacher Ration 74	- .172	- .70
IQ * Texp 76	- .001	- .72
IQ * Texp 75	- .001	- .94
IQ * Texp 74	.001	1.16
IQ * Texp 73	- .0005	- .45
IQ * Hdeg 76	.027	.92
IQ * Hdeg 75	.045	1.49
IQ * Hdeg 74	- .015	- .51
IQ * Hdeg 73	- .00009	- .00
IQ * College Rating 76	.001	.06
IQ * College Rating 75	.021	.74
IQ * College Rating 74	.022	.70
IQ * College Rating 73	.018	.64

Dependent Variable: 1976 Composite Achievement Score on Iowa Test of Basic Skills, constant = -31.40; R^2 = .912; n = 994

[a]School 76 was the school the student attended in 1976. There were 45 separate schools; however, none of these were significant at the .05 level.

[b]A majority of the observations were at 270, (i.e., the instructors' undergraduate college was rated at 270) thus the break had to be made at 300.

TABLE B-5

Black Eighth Grade Sample - Years of Teacher Experience

Years of Experience	1976 Teacher	Percent	1975 Teacher	Percent	1974 Teacher	Percent	1973 Teacher	Percent
1	37	4.1	--	--	13	1.4	62	6.9
2	--	--	16	1.8	63	7.0	128	14.4
3	11	1.2	62	6.9	120	13.5	82	9.2
4	36	4.0	109	12.2	82	9.2	50	5.6
5	98	11.0	70	7.8	70	7.8	42	4.7
6	44	4.9	92	10.3	36	4.0	70	7.8
7	56	6.3	21	2.3	68	7.6	32	3.6
8	34	3.8	25	2.8	52	5.8	46	5.1
9	73	8.2	97	10.9	54	6.0	59	6.6
10	35	3.9	53	5.9	57	6.4	4	.450
11	68	7.6	62	6.9	1	.113	18	2.02
12	68	7.6	28	3.1	14	1.5	6	.676
13	12	1.3	15	1.6	2	.225	7	.788
14	3	.338	25	2.8	13	1.4	7	.788
15	44	4.9	12	1.3	13	1.4	28	3.1
16	3	.338	5	.563	13	1.4	20	2.2
17	10	1.1	--	--	4	.450	24	2.7
18	1	.113	9	1.0	38	4.2	24	2.7
19	16	1.8	24	2.7	17	1.9	5	.563
20	36	4.0	25	2.8	4	.450	18	2.0

TABLE B-5 (Continued)

Years of Experience	1976 Teacher	Percent	1975 Teacher	Percent	1974 Teacher	Percent	1973 Teacher	Percent
21	18	2.0	--	--	18	2.0	--	--
22	1	.113	4	.450	17	1.9	10	1.1
23	2	.225	16	1.8	19	2.1	6	.676
24	13	1.4	14	1.5	18	2.0	7	.788
25	2	.225	10	1.1	12	1.3	11	1.2
26	37	4.1	5	.563	4	.450	18	2.0
27	8	.901	11	1.2	--	--	23	2.5
28	23	2.5	8	.901	--	--	35	3.9
29	1	.113	4	.450	26	2.9	12	1.3
30	21	2.3	23	2.5	5	.563	--	--
31	8	.901	8	.901	8	.901	--	--
32	--	--	5	.563	8	.901	2	.225
33	--	--	--	--	6	.676	--	--
34	1	.113	2	.225	--	--	13	1.4
35	7	.788	--	--	2	.225	3	.338
36	--	--	1	.113	--	--	--	--
37	22	2.4	12	1.3	--	--	2	.225
38	25	2.8	11	1.2	--	--	5	.563
39	14	1.5	--	--	11	1.2	1	.113
40	--	--	4	.450	--	--	5	.563
41	--	--	--	--	--	--	2	.225

TABLE B-5 (Continued)

Years of Experience	1976 Teacher	Percent	1975 Teacher	Percent	1974 Teacher	Percent	1973 Teacher	Percent
42	--	--	--	--	--	--	--	--
43	--	--	--	--	--	--	--	--
44	--	--	--	--	--	--	1	.113

TABLE B-6

Black Eighth Grade Sample - Level of Education

1976 Teacher	Frequency	Percent
Baccalaureate Degree	571	64.30
Master's, Education Specialist, or Doctor's Degree	317	35.69

1975 Teacher	Frequency	Percent
Baccalaureate Degree	644	75.52
Master's, Education Specialist, or Doctor's Degree	244	27.47

1974 Teacher	Frequency	Percent
Baccalaureate Degree	702	79.05
Master's, Education Specialist, or Doctor's Degree	186	20.94

1973 Teacher	Frequency	Percent
Baccalaureate Degree	685	77.14
Master's, Education Specialist, or Doctor's Degree	203	22.86

TABLE B-7

Eighth Grade Black Sample - Correlations >.7

CS72-IQ .724	CS72-CS75 .792	Schsize 75 - Schsize 76 .871
CS73-IQ .749	CS73-CS75 .824	Title73 - Title74 .882
CS74-IQ .734	CS74-CS75 .854	Title73 - Title75 .706
CS75-IQ .725	CS72-CS74 .779	Title74 - Title75 .779
CS72-CS76 .736	CS73-CS74 .830	Title75 - Title76 .893
CS73-CS76 .783	CS72-CS73 .846	Title74 - Titlels74 .749
CS74-CS76 .815	Schsize 74 - Schsize 75 .775	Titlels74 - Titlels75 .757
CS75-CS76 .853	Schsize 74 - Schsize 76 .720	Tnw75 - Tnw76 .817
Recency 76 - Texp 76 .899		
Recency 75 - Texp 75 .938		
Recency 74 - Texp 74 .858		
Recency 73 - Texp 73 .907		

TABLE B-8

Black Eighth Grade Sample - Structural Equation Estimates with School 76 as a Dummy Variable

Variables		Coefficients	t-Statistics
CS75		.817	24.91
IQ		.295	4.63
School 76[a]		--	--
Sex		.109	.22
Texp 76		.149	.52
Texp 76^2		- .0006	- .16
Texp 75		1.00	2.96
Texp 75^2		- .004	-1.03
Texp 74		.264	.91
Texp 74^2		- .002	- .64
Texp 73		- .149	- .49
Texp 73^2		- .003	-1.18
Hdeg 76	1 if M.A., Ed. Specialist or Ph.D.	6.94	1.41
Hdeg 75		.803	.15
Hdeg 74		4.23	.72
Hdeg 73		- .191	- .03
College Rating 76	1 if ≥ 300[b]	.048	.01
College Rating 75		-7.89	-1.59
College Rating 74		-4.45	- .98
College Rating 73		9.09	1.89
Eddeg 76		.162	.16
Eddeg 75		- .784	- .92
Eddeg 74		.679	.86
Eddeg 73		.324	.41
MeanCS 76		.393	5.37
MeanCS 75		- .140	-1.91
MeanCS 74		- .082	-1.44
MeanCS 73		.088	1.46
SDCS 76		- .064	- .30
SDCS 75		.148	.77
SDCS 74		.078	.40
SDCS 73		.012	.06
Class Size 76	1 if ≥ 30	1.54	1.30
Class Size 75		- .460	- .53
Class Size 74		- .296	- .45
Class Size 73		- .220	- .34
TitleIs75		- .006	- .74
TitleIs74		.014	1.76
Attend 75		- .191	- .47
Attend 74		.275	- .97
TAttend 75		- .008	- .02
TAttend 74		- .114	- .47
Tnw 75		.031	.70

TABLE B-8 (Continued)

Variables	Coefficients	t-Statistics
Schsize 75	.0006	.14
Schsize 74	- .002	- .79
Pupil/Ratio 75	- .018	- .08
Pupil/Ratio 74	.369	1.58
IQ * Texp 76	- .0008	- .34
IQ * Texp 75	- .008	-2.92
IQ * Texp 74	- .001	- .51
IQ * Texp 73	.003	1.04
IQ * Hdeg 76	- .075	-1.44
IQ * Hdeg 75	- .002	- .03
IQ * Hdeg 74	- .030	- .48
IQ * Hdeg 73	.005	.08
IQ * College Rating 76	- .013	- .26
IQ * College Rating 75	.083	1.58
IQ * College Rating 74	.055	1.12
IQ * College Rating 73	- .092	-1.79

Dependent Variable: 1976 Composite Achievement Score on Iowa Test of Basic Skills, constant = -39.68; R^2 = .832; n = 758

[a]School 76 was the school the student attended in 1976. There were 62 separate schools; however, none were significant at the .05 level.

[b]A majority of the observations were at 270, (i.e., the instructors' undergraduate college was rated at 270) thus the break had to be made at 300.

TABLE B-9

Black Seventh Grade Sample - Years of Teacher Experience

Years of Experience	1976 Teacher	Percent	1975 Teacher	Percent	1974 Teacher	Percent	1973 Teacher	Percent
1	113	6.7	23	1.3	8	.494	140	8.5
2	--	--	32	1.9	52	3.2	170	10.3
3	24	1.4	128	7.6	182	11.2	145	8.8
4	93	5.5	149	8.9	156	9.6	127	7.7
5	183	11.0	112	6.7	111	6.8	112	6.8
6	113	6.7	85	5.0	71	4.3	110	6.6
7	178	10.7	68	4.0	96	5.9	39	2.3
8	52	3.1	104	6.2	81	5.0	138	8.3
9	79	4.7	81	4.8	105	6.5	53	3.2
10	126	7.5	101	6.0	86	5.3	43	2.6
11	55	3.3	96	5.7	58	3.5	77	4.6
12	87	5.2	1	.060	53	3.2	51	3.1
13	83	4.9	31	1.8	48	2.9	16	.973
14	41	2.4	39	2.3	49	3.0	36	2.1
15	63	3.7	66	3.9	44	2.7	7	.426
16	53	3.1	44	2.6	8	.494	37	2.2
17	20	1.2	38	2.2	25	1.5	9	.547
18	--	--	50	2.9	8	.494	14	.851
19	34	2.0	67	4.0	18	1.1	27	1.6

TABLE B-9 (Continued)

Years of Experience	1976 Teacher	Percent	1975 Teacher	Percent	1974 Teacher	Percent	1973 Teacher	Percent
20	15	.902	25	1.4	19	1.1	19	1.1
21	23	1.3	35	2.0	53	3.2	10	.608
22	14	.842	51	3.0	28	1.7	4	.243
23	7	.421	50	2.9	49	3.0	2	.122
24	25	1.5	11	.659	3	.185	24	1.4
25	--	--	28	1.6	29	1.7	14	.851
26	15	.902	13	.779	34	2.0	4	.243
27	15	.902	4	.240	8	.494	64	3.8
28	33	1.9	25	1.4	33	2.0	10	.608
29	37	2.2	16	.959	21	1.2	4	.243
30	--	--	17	1.0	8	.494	16	.973
31	29	1.7	4	.240	1	.062	--	--
32	2	.120	17	1.0	21	1.2	8	.486
33	34	2.0	30	1.7	--	--	36	2.1
34	--	--	--	--	1	.062	16	.973
35	--	--	--	--	13	.802	23	1.3
36	--	--	17	1.0	17	1.0	--	--
37	1	.060	--	--	--	--	7	.426
38	--	--	2	.120	--	--	13	.790
39	16	.962	--	--	12	.741	--	--

TABLE B-9 (Continued)

Years of Experience	1976 Teacher	Percent	1975 Teacher	Percent	1974 Teacher	Percent	1973 Teacher	Percent
40	--	--	7	.420	3	.185	--	--
41	--	--	--	--	6	.370	10	.608
42	--	--	--	--	--	--	--	--
43	--	--	--	--	--	--	1	.061
44	--	--	1	.060	1	.062	9	.547
missing data	74		69		117		92	

TABLE B-10

Black Seventh Grade Sample - Level of Education

1976 Teacher	Frequency	Percent
missing data	74	
Baccalaureate Degree	1301	78.23
Master's, Education Specialist, or Doctor's Degree	362	21.76

1975 Teacher	Frequency	Percent
missing data	69	
Baccalaureate Degree	1300	77.93
Master's, Education Specialist, or Doctor's Degree	368	22.06

1974 Teacher	Frequency	Percent
missing data	117	
Baccalaureate Degree	1368	84.44
Master's, Education Specialist, or Doctor's Degree	252	15.55

1973 Teacher	Frequency	Percent
missing data	92	
Baccalaureate Degree	1451	88.20
Master's, Education Specialist, or Doctor's Degree	194	11.79

TABLE B-11

Seventh Grade Black Sample - Correlations >.7

CS73-IQ .700	CS72-CS74 .759	Title75 - Title76 .783
CS74-IQ .701	CS73-CS74 .830	Title74 - Titlels74 .720
CS73-CS76 .753	CS72-CS73 .789	Title75 - Titlels75 .712
CS74-CS76 .805	Schsize 74 - Schsize 75 .722	Titlels74 - Titlels75 .756
CS75-CS76 .833	Schsize 74 - Schsize 76 .700	Tnw75 - Tnw76 .745
CS72-CS75 .713	Schsize 75 - Schsize 76 .851	Recency 76 - Texp 76 .904
CS73-CS75 .798	Title73 - Title74 .717	Recency 75 - Texp 75 .881
CS74-CS75 .865	Title74 - Title75 .800	Recency 74 - Texp 74 .911
		Recency 73 - Texp 73 .919

TABLE B-12

Black Seventh Grade Sample - Structural Equation Estimates with School 76 as a Dummy Variable

Variables		Coefficients	t-Statistics
CS75		.803	29.58
IQ		.278	4.75
School 76[a]		--	--
Sex		.550	1.42
Texp 76		.415	1.46
Texp 76^2		- .005	-1.33
Texp 75		.156	.61
Texp 75^2		.001	.48
Texp 74		- .035	- .16
Texp 74^2		.004	1.60
Texp 73		.441	2.16
Texp 73^2		- .002	-1.01
Hdeg 76	1 if M.A., Ed. Specialist or Ph.D.	1.52	.29
Hdeg 75		3.25	.74
Hdeg 74		-4.20	- .80
Hdeg 73		-3.77	- .52
College Rating 76	1 if ≥ 300[b]	-4.15	.35
College Rating 75		-3.88	.71
College Rating 74		2.95	- .94
College Rating 73		1.44	- .85
Eddeg 76		1.07	1.34
Eddeg 75		- .066	- .09
Eddeg 74		- .400	- .51
Eddeg 73		- .169	- .25
MeanCS 76		.227	3.43
MeanCS 75		- .112	-1.85
MeanCS 74		.031	.54
MeanCS 73		.025	.50
SDCS 76		.160	.75
SDCS 75		.101	.57
SDCS 74		.031	.19
SDCS 73		- .263	-1.61
Class Size 76	1 if ≥ 30	- .399	- .44
Class Size 75		- .466	- .74
Class Size 74		- .070	- .12
Class Size 73		- .070	-1.29
Titlels75		- .006	-1.08
Titlels74		- .004	- .77
Attend 75		.167	.75
Attend 74		.134	.61
TAttend 75		.073	.34
TAttend 74		.052	.32
Tnw 75		.014	.44

TABLE B-12 (Continued)

Variables	Coefficients	t-Statistics
Schsize 75	.002	1.03
Schsize 74	.001	.79
Pupil/Teacher Ratio 75	-.147	-1.14
Pupil/Teacher Ratio 74	.084	.66
IQ * Texp 76	-.002	-1.04
IQ * Texp 75	-.001	-.78
IQ * Texp 74	-.001	-.59
IQ * Texp 73	-.004	-2.12
IQ * Hdeg 76	.020	.38
IQ * Hdeg 75	-.036	-.77
IQ * Hdeg 74	.045	.81
IQ * Hdeg 73	.035	.47
IQ * College Rating 76	.037	.73
IQ * College Rating 75	.047	1.08
IQ * College Rating 74	-.034	-.77
IQ * College Rating 73	-.016	-.38

Dependent Variable: 1976 Composite Achievement Score on Iowa Test of Basic Skills, constant = -54.96; R^2 = .830; n = 891

[a]School 76 was the school the student attended in 1976. There were 68 separate schools, 10 of which had statistically significant coefficients. Of these ten, seven were significantly negative. Examination of these schools' characteristics revealed no obvious clues to explain their importance in the prediction of seventh grade black achievement.

[b]A majority of the observations were at 270, (i.e., the instructor's undergraduate college was rated at 270) thus the break had to be made at 300.

Table B-13
Descriptive statistics as selected variables from the Five/Six year sample and the Remaining Longitudinal History File

Variables	Five/Six Year Sample		Longitudinal History File	
	mean	standard deviation	mean	standard deviation
1971-Grade 3				
CS71	36.6	8.7	35.1	8.2
mean CS71	35.6	5.4	35.0	5.2
Texp 71	13.6	11.3	12.8	10.8
1971-Grade 4				
IQ	95.2	13.2	88.3	13.8
CS71	44.4	9.7	41.8	9.2
mean CS71	43.2	6.3	42.1	5.7
mean IQ71	92.1	8.3	89.7	7.1
Texp 71	13.0	11.1	12.4	10.4
1972-Grade 3				
CS72	36.8	8.8	35.4	8.6
mean CS72	35.9	5.7	35.5	5.3
Texp 72	13.0	10.7	12.6	10.6
1972-Grade 4				
IQ	95.8	13.4	90.9	13.6
CS72	46.3	9.9	43.2	9.5
mean CS72	44.8	6.1	43.4	5.4
mean IQ72	93.4	7.4	91.5	6.8
Texp 72	12.7	11.5	11.7	10.9
1973-Grade 4				
IQ	93.9	12.9	90.4	14.0
CS73	45.9	9.9	42.8	10.0
mean CS73	44.2	6.1	43.1	5.8
mean IQ73	92.1	7.4	91.1	7.3
Texp 73	11.9	11.0	11.3	10.6
1973-Grade 5				
IQ	95.7	13.5	90.3	13.5
CS73	55.9	11.3	51.4	10.9
mean CS73	54.0	7.3	52.0	6.2
mean IQ73	93.6	8.3	91.5	6.9
Texp 73	11.9	10.5		9.0
1974-Grade 5				
IQ	94.1	12.9	89.8	14.0
CS74	53.6	11.1	49.5	11.1
mean CS74	51.7	7.2	50.3	6.8
mean IQ74	92.1	7.9	90.8	7.1
Texp 74	13.2	10.2	11.6	9.6

Table B-13 (Continued)

Variables	Five/Six Year Sample		Longitudinal History File	
	mean	standard deviation	mean	standard deviation
1974-Grade 6				
IQ	95.8	13.5	90.0	13.4
CS74	64.3	12.6	58.6	12.0
mean CS74	62.4	8.1	59.6	6.9
mean IQ74	94.0	8.3	91.2	6.6
Texp 74	12.2	9.8	10.5	8.8
1975-Grade 6				
IQ	94.3	12.8	89.6	14.3
CS75	63.4	12.4	58.2	12.4
mean CS75	61.2	7.9	59.5	7.4
mean IQ75	92.5	7.6	91.1	7.1
Texp 75	13.6	10.0	12.6	9.7
1975-Grade 7				
IQ	97.0	13.4	92.4	13.1
CS75	73.9	14.0	68.2	13.6
mean CS75	71.6	9.2	70.4	7.6
mean IQ75	95.2	8.5	94.1	7.0
Texp 75	13.4	9.8	12.9	9.3
1976-Grade 7				
IQ	96.2	12.8	92.1	13.6
CS76	73.3	13.4	67.5	14.0
mean CS76	71.0	8.7	69.6	8.6
mean IQ76	94.5	8.2	93.6	7.8
Texp 76	12.2	8.8	11.4	8.7
1976-Grade 8				
IQ	96.6	13.6	91.4	13.2
CS76	82.2	15.7	74.6	15.2
mean CS76	79.7	10.7	76.1	9.1
mean IQ76	95.0	8.7	92.6	7.1
Texp 76	15.6	9.9	14.9	9.5
	N	%	N	%
Race				
Black	4494	68	33,591	77
White	2111	32	9,903	23
Missing Data	1597	-	39,899	-
Sex				
0	3993	49	41,660	50
1	4193	51	41,218	50
Missing Data	16	-	515	-

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