Dennis J. Dugan*

Parents provide a home environment that contributes to the scholastic success of their child (ren). This relationship between home-environment and achievement is well-known, and scholastic achievement has generally been assumed to flow directly from the socio-economic characteristics of parents and a complement of school resources. In this paper the mechanism that parents employ to transmit the "potential-forlearning" to their children is considered explicitly within the context of a theoretical model of the education process. Further, a method to measure the educational services that parents provide their child(ren) in the home environment is presented.

The first section of the paper is devoted to the derivation of estimates value of parental investments into the education process. The value of these investments is determined by the opportunity cost of the time that parents devote to the stimulus-response-reinforcement activities of their child(ren) during both the pre-school and formal-education years. The analysis of the components of the total cost of education, including the educational services contributed by the parents, indicates that school expenditures account for less than 50 percent of the total investment in education. In the second section of the paper, the education process is defined in terms of a theoretical model which explains achievement differences by variations in the contributed educational services of parents and school resources. The model is estimated empirically for the white and nonwhite student populations, and the relative effectiveness of educational investments is determined. The statistical results indicate that the educational services of parents are highly significant determinants of scholastic achievement. The empirical results also demonstrate that nonwhite scholastic performance would be significantly increased if the nonwhites had the same level of parental services and school resources as the white students have.

TOTAL INVESTMENT IN THE EDUCATION PROCESS

While the significance of genetically or congenitally determined resources which the individual child has at his disposal is not discounted herein, the main concern of this paper is with the educational processes of the home environment--factors particularly relevant in determining the form his ability will take. The education process is conceived to be a complex process of long gestation in which school and parental investments are combined to produce scholastic achievement, the final product of the educational system.

Taking a close look at the entire educational process, one sees a long formation period in which the student accumulates educational investments and builds upon his previous experiences. This experience is not limited to formal schooling alone and, undoubtedly, it relies heavily upon the home environment of the child and his pre-dispositions towards learning that are acquired in the home. If, in fact, education is more than time and resources provided by the school, then current expenditures per student do not reflect all, nor necessarily a large portion, of the costs that are directly relevant to the educational process. Therefore, "equal educational opportunity" is not brought about simply by equalizing school expenditures among students.

There is substantial evidence¹ that preschool experience and home environment contribute to a child's success in school. These two activities are dependent upon services rendered by the child's mother and father--services that require time and effort that could be devoted to alternative activities. The value of such services and their marginal contribution to educational output are particularly important for public educational policy which has the goal of presenting "equal educational opportunity to all members of our society."

Under this expanded view of the educational process, total educational investment may be substantially greater than formal schooling expenditures. This is especially true if the mother spends five to six years--which she ordinarily does--preparing the child for formal schooling. The value of the educational services provided by the mother is a social cost which would be reflected by a higher level of Gross National Product (GNP) had the mother been working in an occupation that is tallied in national income accounts. A mother has alternative employment opportunities that are consciously by-passed to stay with her child (ren). The net value of the mother's educational services to society is not zero, and they may be approximated by determining the value of her services in an alternative form of employment,² that is, by calculating the earnings that she foregoes to provide the educational services for her child(ren).

The father also provides educational services to the child in the home. These paternal services have a social value and that value is estimated by the father's opportunity cost of extended participation in the labor force.

The total educational investment in a student, therefore, is the accumulated sums of the educational contributions of the mother, the father, and the school. The total investments of these three factors are significant not only because they sum to the aggregate educational investment, but also because they indicate the nature of the separate resources that may have an impact upon scholastic achievement.

Measures of Parental Investment

Age and education are used as predictors of the foregone earnings of parents, and these

earnings are used as a measure of parental opportunity costs. Age-earnings profiles by level of education in the U.S. typically resemble those in Figure 1.



Figure 1. Typical Age-Earnings Profiles by Levels of Education

These profiles have three striking characteristics:

- Earnings, irrespective of the level of education, increase with age up to a maximum and then decline. The obvious explanation is that age acts as a proxy for work experience, raising earnings until infirmity or educational obsolescence sets in.
- (2) The higher the educational attainment, the higher the starting salary and the steeper the rise in earnings throughout the early phases of working life.
- (3) The higher the educational attainment, the later the year at which maximum earnings are reached and the gentler the decline of earnings from the maximum point.

For the mother who provides educational services in the pre-school years of her children, the value of her contributed services may not be the entire amount of income that she is capable of earning by offering her services to the "open" labor market. The mother provides other services in the home besides those that are directly attributable to the education formation of her offspring. Household activities such as washing, cooking, and cleaning are productive economic activities that should not be included in the "opportunity cost" of the maternal contributed educational services. A study of the time-allocation of housewives with young children, under age six, indicates that the mother spends approximately 43 percent of her time in activities directly related to her children--time which is devoted to some type of communication or contact between herself and her child(ren).³ These stimulus-response-reinforcement activities in the home provide a potential-for-learning to the child and may be an important determinant of achievement in school.

A recent study⁴ indicates that when children are in school the mother devotes 5 percent of her economically productive time (the time she would have spent in the labor force if she worked full time) to the educational activities of her children. It was assumed that the father offers a constant 5 percent of his working time to the education activities of his children during their pre-school and formal education years. These parental services are divided up among the children in the family.

The worth of the contributed services of the parents for a given period of time \underline{t} is earnings from alternative employment opportunities, that is, the "opportunity cost" of participating in the labor force more fully instead of devoting these resources to the child. The opportunity cost concept need not consider more participation in the labor force as the only viable alternative to homework. Leisure time, with its implicit value, is another alternative use of time that may be pursued by parents.⁵ The Contributed Educational Services of the Mother is defined as:

(1)
$$M_t = a_t Y_t$$

where \underline{Y}_t is the mother's "opportunity cost," the income she could be earning by participating fully in the labor force and \underline{a}_t represents a combination of factors that determine how much of the mother's time is devoted to each of her children. These factors include: (1) the proportion of a mother's time devoted to educationally-related activities (as opposed to household chores), and (2) the number of children among whom the mother's time is divided. The \underline{a}_t is not a constant, and it will vary over time when a mother has more children in the home and when these children leave the pre-school environment.

The mother's contributed educational services are divided into two distinct units: the preschool portion in which the mother spends a considerable amount of time with her pre-school children; and the mother's time provided during the formal schooling years of her children. The contributed services of the mother may now be looked upon as the sum of these two time intervals, one from birth to age six and the other from age six to age eighteen.

(2)
$$M = \sum_{t=0}^{5} a_t Y_t (1+i) + \sum_{t=0}^{18-t} b_t Y_t (1+i)$$

where \underline{a}_{t} represents the fraction of the mother's time devoted to a child in the pre-school situation and \underline{b}_t represents the fraction of the mother's time devoted in the formal schooling period. For the pre-school period, it is assumed that the mother spreads 43 percent of her productive time among the pre-school children in the home. Vital statistics from the U.S. Census of Population gives a breakdown of average spacing of children and the number of children by the educational attainment and race of the mother. That information determines the size of the constant, $\underline{a_t} \cdot \underline{6}^{/} \underline{b_t}$ is a fraction that indicates the proportion of the mother's time devoted to her children during their school years. It is assumed that mothers divide 5 percent of their time equally among their school-age children.

The contributed educational services of parents are accumulated at a positive rate of interest, $\underline{1}$, to indicate that alternative investment opportunities are available to parents and that these parental resources need not be devoted to embodying human capital in their children. For estimation purposes, $\underline{1}$ is assumed to be a constant 6 percent.

The father's contributed educational services is derived in the same manner:

(3)
$$F = \sum_{t=0}^{18} c_t I_t (1+i)$$

where \underline{F} is the accumulated value of the father's contributed services, \underline{I} the "opportunity cost" of the services or the father's salary, and $\underline{c_t}$ is the portion of the father's time devoted to the educational activities of each child.

The accumulated maternal contributed services to a student at different grade levels according to the educational attainment of the mother is shown in Table 1. This table is based upon 1960 Bureau of the Census data which crossclassifies the years of educational attainment and number of children of mothers. Appendix B presents these data which show the inverse relation between a mother's educational attainment and the number of her children. At grade 1, the student has accumulated varying amounts of educational services from his mother depending on her level of educational attainment. The services rendered in the pre-school years from a mother with five plus years of college are worth \$9,322 according to our opportunity cost concept of valuing these services. A mother with 0-7 years of education, by contrast, has provided \$2,723 worth of educational services to a first grader.

Over the education cycle of the student, the accumulated educational services of the mother grow as she provides a limited number of educational services in the home--an average of 20 minutes per day compared to an average of three hours per day in the pre-school years of her children.

There are substantial differences in the value of contributed educational services per child between whites and nonwhites. The nonwhite mother's level of educational attainment is, on the average, lower than that of the white mother and her earning power at a given level of educational attainment is generally lower than that of a white mother. She is also likely to have more children. Part of these differences between white and nonwhite earnings structures may be attributed to discrimination, but part of it is due to the poorer quality of the nonwhite's educational experience. Therefore, for this analysis of the total cost of education, the population was stratified according to white and nonwhite classifications. The average level of educational attainment of a white mother is 11.2 years and it is 8.5 years for nonwhite. At grade one the accumulated educational services of white and nonwhite mothers with the above-mentioned years of educational attainment are \$4,991 and \$2,508, respectively. Since the average nonwhite mother has more children than the average white mother, the differences between the embodied capital of white and nonwhite first graders are quite pronounced.

The Total Costs of Education

The mother's and father's contributed educational services and the accumulated resources expended by the school⁷ are tallied in Table 2 for grade 12, by the level of parents' educational attainment. At grade 12 the accumulated per pupil school expenditure totals \$6,921 for the average student. School costs, as a percent of total educational costs, vary from 51 percent for a student whose parents have 0-7 years of education to 21.8 percent in the case where both parents have attained five plus years of college. The mother's contribution to total cost ranges from 34 percent to 49 percent for her 0-7 years and five plus years of college, respectively. The father's factor share increases with his level of educational attainment, between 12 and 21 percent.

The total costs of educational services (school plus contributed educational services of parents) for all grade levels are in the order of two to three times larger for students

Grade				
1	6	9	12	
\$2,723.50	\$ 3,411.61	\$ 4,126.38	\$ 4,988.87	
3,378.67	4,231.37	5,135.45	6,235.03	
-	-		-	
3,972.14	5,012.26	6,093.91	7,408.66	
			-	
6,963,71	8,898.18	10,796.85	13,080.38	
7,090.81	9,050.96	10,995.03	13,362.96	
9,043.76	11,560.35	14,075.54	17,147.79	
9,321.80	11,919.85	14,643.85	17,977.84	
	1 \$2,723.50 3,378.67 3,972.14 6,963,71 7,090.81 9,043.76 9,321.80	Gra 1 6 \$2,723.50 \$ 3,411.61 3,378.67 4,231.37 3,972.14 5,012.26 6,963,71 8,898.18 7,090.81 9,050.96 9,043.76 11,560.35 9,321.80 11,919.85	Grade 1 6 9 \$2,723.50 \$3,411.61 \$4,126.38 3,378.67 4,231.37 5,135.45 3,972.14 5,012.26 6,093.91 6,963,71 8,898.18 10,796.85 7,090.81 9,050.96 10,995.03 9,043.76 11,560.35 14,075.54 9,321.80 11,919.85 14,643.85	

Value⁸ in 1965 of Mother's Accumulated Contributed Educational Services for Mother's Educational Attainment, by Grade of Child

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12	ום	2	۷.	

Factor Shares and Total Cost of Educational Inputs of Grade 12 for Educational Attainment of Parents (All figures are %'s, unless otherwise_noted)

	Mother		Mother		Total
Education of Parents	(Pre-school)	Father	(Other)	School	Costs
0-7 years	34.30	12.17	2.49	51.04	\$13,540.83
8 years	36.82	15,49	3.22	44.46	15,567.63
1-3 years of high					
school	32,83	18,24	9.44	39.49	17,527.01
4 years of high					
school	49.49	17,58	4.41	28,52	24,269.02
1-3 years of college	48,24	19.52	4.78	27,46	25,203.26
4 years of college	49.67	22,21	5,75	22.37	30,942.18
5+ years of college	49,11	21.45	7.61	21.84	31,696.98

with parents having completed college than those having only some elementary education. At Grade 1, the ratio is approximately three to one and it diminishes slightly as the student proceeds to higher grades. The disadvantaged student, one whose parents have little education, remains disadvantaged throughout his educational career, even though this disadvantage may diminish over time. This analysis of the total costs of education indicates that equalization of school resources devoted to the culturally advantaged and disadvantaged may not eliminate educational deficiencies nor insure equality of educational opportunity.

A NEW MODEL OF ACHIEVEMENT

The Equality of Educational Opportunity Survey(6), popularly known as the Coleman Report, stimulated a great deal of research concerning the determinants of scholastic achievement. While Coleman tended to minimize the influence of the characteristics of schools upon achievement, Bowles(4) and Bowles and Levin(5) emphasize the relationship between various school inputs and achievement. Specifically, Bowles(4) adjusts for the combined effects of the student's genetic ability and environmental influences prior to age six be introducing first grade verbal achievement test scores. He arrives at the flow of scholastic achievement from grade 1 to grade 12 for black male students. Bowles' empirical "education production function" links a number of school variables, such as teacher's verbal ability score and science lab facilities, to achievement.

In this section a theoretical model of the education process is presented and one of the determinants of school outcomes is the homeembodied capital of students. Since the education process builds on what has gone before, the determinants of achievement should be specified in a form that reflects this gradual enlargement of the student's education base. Therefore, the appropriate variables to explain differences in school outcomes are the accumulated educational investments of parents and accumulated school resources. Thus, the education process is envisaged here as an educational "learning-bydoing" model where parental and school investments, both past and present, act as positive reinforcement for the student's academic success.

The model may be specified formally in the following functional form:

(4)
$$A_{i} = f(M, F, S)$$

where \underline{A}_{i} is a suitable measure of school outcomes for grade i, M and F are respectively the contributed educational services of the mother and the father, and S is the accumulated school resources provided the student. Since measures of achievement, the outcome of schooling, is a stock variable, parental and school services are expressed in stock terms to maintain consistency. The hypothesis to be tested may be stated simply: the contributed educational services of parents and school resources jointly determine the scholastic achievement of a student. This hypothesis has been postulated in such a manner that it is empirically testable under a number of alternative formulations of the basic relationship in equation (4).

The exact functional form that the relationship in equation (4) assumes is not predetermined by a theory of learning. Two mathematical forms of that relationship, however, have immediate theoretical appeal because of the interpretations that may be given to their empirical results. One functional form of the relationship between achievement and parental and school investments is linear where the variables enter separately and linearly:

(5)
$$A_{i} = \alpha_{i0} + \alpha_{i1} M + \alpha_{i2} F + \alpha_{i3} S + U_{i}$$

where \underline{U}_{i} is the unobserved, statistical disturbance term and the i's refer to school grades. The coefficients of this linear model are statistically estimated by the application of multiple regression analysis. Since all the independent variables in the linear model are scaled in dollar terms, their estimated coefficients will yield a direct answer as to what scarce educational resource yields the largest increment in achievement. The α 's may appropriately be called "benefit-cost" coefficients because each indicates the change in school outcomes due to a change in the unit cost of investment in that resource. Underlying this linear model is the assumption that the school's influence upon achievement is independent of the home environment and the homeenvironment influence is independent of the school. Insofar as the linear model truly represents the education process, then the variable with the largest α would merit all available educational resources to achieve the greatest impact upon school outcomes.

Another function form that this relationship may assume is the following nonlinear one:

(6)
$$A_i = \beta_{10} M^{\beta i l} F^{\beta i 2} S^{\beta l 3} U_i$$

which is easily transformed into a linear-in-thelogarithms function which may be empirically estimated by regression analysis:

(7)
$$\ln A_i = \ln \beta_{i0} + \beta_{i1} \ln M + \beta_{i2} \ln F + \beta_{i3} \ln S + V_i$$

where <u>ln</u> refers to the natural logarithm of the appropriate variable, and \underline{V}_1 is the natural logarithm of \underline{U}_1 .

This logarithmic model has theoretical appeal because it takes into account diminishing returns to the resources, that is, the intensity of an educational service, provided by a parent or the school, may be instrumental in determining its marginal contribution to scholastic achievement. This model also allows for some interaction among the independent variables in determining school outcomes and the degree of substitution among the determinants is restricted by technological and structural considerations. In the linear model the degree of substitution among those who provide educational services is virtually unlimited.

The alternative formulations of the learning model that appears in equations (5) and (7) are theoretically consistent with the hypothesis stated above. Both take into account the previous educational experiences of the student and build a scholastic record upon these prior investments. Each formulation of the model has its specific theoretical interpretation, and the statistical analyses of the two equations may indicate what model best explains the hypothesis.

This paper utilizes the information from the Equality of Educational Opportunity Survey to identify the home characteristics of students and to associate these with the results of achievement tests given to the students. This survey of the Nation's public elementary and secondary schools was conducted in the Fall of 1965 by the U.S. Office of Education, at the direction of Congress. The survey entailed the testing and surveying of about 650,000 students in some 4,000 public schools throughout the country in grades 1, 3, 6, 9, and 12. In the analysis that follows, grade 3 is omitted because the results of the achievement test of that grade have been thrown into a questionable light. The survey sample consisted of a 5 percent sample of schools and the information was comprehensive in that factual information was collected on the students' home background, such as education and occupation of parents.

The educational attainment of parents was listed in eight categories ranging from zero-toseven-years-of-education to five-plus-years-ofcollege. It is possible to infer earnings from the Coleman data on parent's educational attainment and the 1960 U.S. Census of Population data on earnings by age and educational attainment of men and women.

The school outcome variable used in the analysis is verbal achievement,⁹ and the learning model is statistically estimated for grades 1, 6, 9, and 12, white and nonwhite students separately. Linear Education Model, Student Verbal Achievement As A Function Of The Educational Services Of Parents And School Resources: Grade 1,6,9, And 12, White and Nonwhite Regressions

$$A_{i} = \alpha_{i0} + \alpha_{i1}M + \alpha_{12}F + \alpha_{i3}S + U_{i}$$

Grade Level,	Regression Co	pefficients (t-	-statistic	s in parent	heses)	
White and	Mother's	Father's	School		X'X	R ²
Nonwhite	Educational	Educational	Resource	s Constant		
	Services	Services				
Grade 1	.0003	.0019		16.0606	.058	.888
(White)	(153.70)	(147.90)				
Grade 1	.0003	.0033		14.2593	.075	.875
(Nonwhite)	(100.24)	(153.14)				
Grade 6	.0005	.0023	.0335	-38.7431	.087	.792
(White)	(144.62)	(141.67)	(63.01)			
Grade 6	.0002	.0017	.0168	-10,8825	.246	.499
(Nonwhite)	(30.95)	(37.68)	(74.55)			
Grade 9	.0007	.0026	.0048	3.5223	.043	.914
(White)	(362.66)	(354.88)	(21.77)			
Grade 9	.0005	.0022	.0033	4.0680	.094	.785
(Nonwhite)	(138.96)	(116.57)	(42.05)			
Grade 12	.0006	.0018	0020	33.4004	.055	.902
(White)	(339.77)	(333.77)	(-13.20)			
Grade 12	.0005	.0018	.0015	9.1227	.095	.791
(Nonwhite)	(150.02)	(103.35)	(20.56)			

Notation:

 R^2 - Coefficient of determination

X'X - determinant * of zero - order correlation matrix

* This determinant is a test for the presence of multicollinearity. If the determinant approaches zero there is evidence of severe multicollinearity. When it is equal to unity, perfect orthogonality exists.

TABLE 4

The Marginal Rates of Substitution Among Parental Educational Services and School Resources for Linear Model: Grade 1, 6, 9, and 12, White and Nonwhite Students

Grade Lev	Level, White Marginal Rates of Substitu		stitution	
and Nonwhite		α ₂ /α ₁	α ₃ /α ₁	^a 3/ ^a 2
Grade 1	(White)	6.3		
Grade 1	(Nonwhite	11.0		
Grade 6	(White)	4.6	67.0	14.6
Grade 6	(Nonwhite)	8.5	84.0	9.9
Grade 9	(White)	3.7	6,9	1.8
Grade 9	(Nonwhite)	4.4	6.6	1.5
Grade 12	(White)	3.0	-3.3	-1.1
Grade 12	(Nonwhite)	3.6	3.0	.8

Notation:

α₂/α₁ - Marginal rate of substitution (linear model) between fathers' and mothers' contributed educational services

 α_3/α_1 - Marginal rate of substitution between school resources and mothers' educational services

 α_3/α_2 - Marginal rate of substitution between school resources and fathers' educational services

The results of the empirical estimation 10 of the linear model are presented in Table 3. The regression coefficients and coefficients of determination are presented there for four grades and for whites and nonwhites. The amount of variation explained by the educational services of parents and school resources is substantial, generally falling within the 80 to 90 percent range. The stability over grades and races of the parental coefficients should be noted, whereas the influence of school resources over the grades is less stable. The impact of the school upon achievement appears to be the greatest at grade 6, for both whites and nonwhites, and it diminishes at grade 9 and again at grade 12, where it actually has a negative influence upon the verbal achievement of white students. This negative coefficient is most likely a statistical artifact caused by the multicollinearity among the independent variables.

The linear relationship in equation (5) implies a constant marginal product of parental and school investments regardless of the intensity of these services. The absolute magnitude of the marginal product may not be a valid analytical concept in this context because the achievement measure is not a cardinal one, there being no well-defined unit of measurement of achievement. The marginal rate of substitution among alternative educational investments may provide us with useful information of parental and school services. The marginal rate of substitution is an indication of the efficiency of one set of educational resources relative to another.

The marginal rate of substitution among investments is the ratio of the marginal product of one investment to the marginal product of another. In our linear model, as specified in equation (5), the marginal rate of substitution between the school and the mother is defined as:

$$(8)\frac{\frac{\delta A_{i}}{\delta S_{i}}}{\frac{\delta A_{i}}{\delta M_{i}}} = \frac{\alpha_{i3}}{\alpha_{i1}}$$

This ratio indicates the marginal contribution of school investments relative to the mother's contributed educational services. This ratio for each grade level and the ratios for the father to the mother and for the school to the father are presented in Table 4.

 α_2/α_1 , the marginal rate of substitution between the contributed educational services of the father and the mother, is greater than 3 at each grade level, for the white and nonwhite alike. The magnitude of the ratio, however, is much different between the grades. The ratio is high for the first and sixth grade nonwhite students. This indicates the substantial amount of influence the presence of the nonwhite male in the home seems to have. The ratio α_3/α_1 shows a diminishing influence of school investments relative to the mothers contribution over the educational life of the student. The α_3/α_1 ratio shows the marginal contribution of schools to be much greater than that of the mother. The marginal rate of substitution between the school and the father is near unity for the ninth and twelfth grades.

If the linear model is a good predictor of achievement, then we do glean some insights into the relative efficiencies of the parental and school investments. The father and the school are relatively more productive than the mother in contributing educational services. On the other hand, the mother's contributed educational services may be over-extended; thus, her relatively small influence upon achievement. If the mother is overextended, one must find a way of making her activity more effective in the years she provides educational services.

The linear formulation of the model does not address itself to the investment intensity problem. In fact, it is this aspect of the linear model that suggests a more refined formulation of the model in which intensities do play a role. Furthermore, a linear model, with its implicit assumption of infinite substitution among the investment alternatives, is based on very tenuous grounds. This has an unrealistic policy implication of choosing the investment alternative that has the largest marginal product and channelling all funds to that particular investment. Such a strategy is neither theoretically satisfying nor practical within the current home-school structure of our society.

The results of the logarithmic formulation of the achievement model are presented in Table 5. On all counts with the single exception of grade 6, nonwhite students, this model has a better statistical fit as measured by higher R2's. The coefficient of determination is but one criteria for judging the goodness-of-fit of these alternative models. There is reason to believe that increases in investments will yield different changes in the achievement depending on their timing. It may be relatively easy to move forward on the lower range of the scale, even assuming that there are no measurement errors in the output variable. Whereas, at higher levels on that scale, movements induced by increased investments may be hard to come by. More importantly, the logarithmic formulation of the model specifies that investment intensities are influential in determining the marginal products of these alternative education investments of parents and school.

Again, because of the uncertain nature of the measurement characteristics of the dependent variable, the size of the marginal product of an investment must be interpreted with care; yet the ratio of the marginal products of two investments is still a valid analytical concept. From equation (7) it is possible to derive ratios of marginal products: Nonlinear Education Model, Student Verbal Achievement As A Function of the Educational Services of Parents and School Resources: Grade 1, 6, 9, and 12, White and Nonwhite Regressions

TABLE 5

Grade Level,	Regression Co	efficients (t-	-statistics	in parenthe	eses)	
White and	Mother's	Father's	School		X'X	R ²
Nonwhite	Educational	Educational	Resources	Constant	• •	
	Services	Services				
Grade 1	.0761	.0781		1.7808	.026	.950
(White)	(256.39)	(205.67)				
Grade 1	.0652	.0801		1.8112	.055	.898
(Nonwhite)	(129.29)	(136.28)				
Grade 6	.1254	.1370	1.2929	-8.3796	.046	.878
(White)	(232.31)	(174.75)	(53.39)			
Grade 6	.0624	.0787	1.1256	-6.4015	.208	.460
(Nonwhite)	(37.42)	(29.26)	(53.47)			
Grade 9	.1989	.2289	.1238	-1.1169	.026	.942
(White)	(468.89)	(407.19)	(6.73)			
Grade 9	.1850	.1721	-,0914	.9012	.062	.805
(Nonwhite)	(180.27)	(112.57)	(-7.67)			
Grade 12	.1639	.1930	7056	6.4826	.043	.918
(White)	(387.84)	(355.78)	(-38.24)			
Grade 12	.2036	.1875	3634	2.9977	.065	.797
(Nonwhite)	(170.34)	(106.52)	(-25.23)			

 $\ln A_{i} = \ln \beta_{i0} + \beta_{i1} \ln M + \beta_{i2} \ln F + \beta_{i3} \ln S + V_{i}$

Notation:

 R^2 - Coefficient of determination

|X'X| - determinant of zero - order correlation matrix

TABLE 6

The Marginal Rates of Substitution Among Parental Educational Services and School Resources For Logarithmic Model: Grades 1, 6, 9, and 12, White and Nonwhite Students

Grade	e Level, White			Marginal Rates of Substitution		
and Nonwhite		β2 ^{M/β1} F	β ₃ M/β ₁ S	β ₂ F/β ₂ S		
Grade	1	(White)	5.7			
Grade	1	(Nonwhite)	6.7			
Grade	6	(White)	3.6	36.9	10.2	
Grade	6	(Nonwhite)	4.5	40.4	9.1	
Grade	9	(White)	3.2	1.6	.5	
Grade	9	(Nonwhite)	2.8	8	3	
Grade	12	(White)	2.97	-8.9	-3.0	
Grade	12	(Nonwhite)	2,5	-2.3	9	

Notation:

 $\beta_2 M / \beta_1 F$ - Marginal rate of substitution (logarithmic model) between father's and mother's educational services

- β₃M/β₁S Marginal rate of substitution between school resources and mother's educational services
- β₃F/β₂S Marginal rate of substitution between school resources and father's educational services

(9)
$$\frac{\frac{\delta A_i}{\delta A_i}}{\frac{\delta A_i}{\delta A_i}} = \frac{\beta_{3i}M_i}{\beta_{1i}S_i}$$

and

(10)
$$\frac{\frac{\delta A_{i}/\delta F_{i}}{\delta A_{i}/\delta M_{i}}}{\frac{\beta_{i2}M_{i}}{\beta_{i1}F_{i}}}$$

Table 6 presents these ratios derived from the logarithmic model where the values of the independent variables are mean values.

The marginal rates of substitution in Table 6 are substantially lower than the marginal rates derived from the linear model, except for the cases where the school coefficient is negative. This is a strong indication of the model specification bias when a linear form is imposed upon a non-linear system. This result is another piece of evidence favoring the non-linear model because it is an indication that factor intensities are prevalent. The better fit plus the uniformly smaller marginal rates of substitutions represent strong evidence in favor of the non-linear model.

The marginal rates of substitution for the non-linear model have the same characteristics as the rates derived from the linear model. The father's contributed educational services are relatively more efficient than the mother's, although this relative efficiency diminishes over the educational life of the student. School resources appear to be more efficient than the mother's contributed services. For grade 6, the school is relatively more efficient than the services of fathers, and this is reversed for the white students at grade 9.

CONCLUSIONS AND POLICY IMPLICATIONS

This paper presented a new model of scholastic achievement that postulated a theory of learning in which the output of schools, student achievement, depended upon past as well as current educational investments which include the contributed educational services of parents and formal education investments. The model was empirically estimated and the results were highly significant in terms of high R²'s and regression coefficients. The achievement model was tested statistically in two mathematical forms, and the non-linear model produced the "best" fit. The empirical results show that the parental investments, as determined by the opportunity costs of the parents' time, are highly significant determinants of scholastic achievement.

This new approach of the determination of scholastic achievement presents an analytical tool to investigate the trade-off between school and parental investments. Such a trade-off is the foundation of compensatory education, for it gives an indication of the amount of school resources required to elevate a culturally deprived child to an achievement level comparable to the national norm.

It is worth noting that in grade 9, if the mean values of the contributed educational services of parents and school resources of white students are put in the nonwhite model, 55.8 percent of the gap between white and nonwhite verbal achievement is eliminated. This is another indication that the potential contribution to educational achievement of the improvement in the economic status of a student's family should not be overlooked by policy makers.

This paper points out that the concept of "equality of educational opportunity" that is currently in vogue is in need of close scrutiny. If it means the quality of current educational expenditures per student, the goal may be achieved simply by designing allocation formulas to ensure such equality. If, however, "equality of educational opportunity" refers to equal access to scholastic achievement, the costs of the compensatory education necessary to facilitate such equality are substantial. The "Great American Dream" does not come cheaply.

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APPENDIX A

Allocation of Mother's Household Time

The allocation of the time used by the housewife is divided among six basic homemaking activities: (1) meal preparation, (2) dishwashing, (3) house care, (4) washing, (5) ironing, and (6) the physical care of the children and other family members. A General Electric Survey¹¹ indicates that a nonworking wife with children under six years old spent 1,135.16 hours per year in the physical care of children. These 21.8 hours per week compares to three hours per week spent on physical care of children by the housewife of a family with children between six and eighteen years. Estimates of the weekly time spent in homemaking by full-time homemakers vary between 50 and 52 hours per week. 12 Therefore, in a 50hour work week of mothers, 43 percent of her time is devoted to the physical care of children.

This estimate of the percent of time devoted by the housewife to the physical care of children may, in fact, understate the value of the educational services provided by the mother. Manual tasks such as meal preparation may, in fact, present situations in which joint production may take place. While preparing meals, it is possible to maintain communication with children and also to present stimulus-response situations by demonstrating techniques to the pre-schooler. Examples of such joint production are too numerous to mention, and they do indicate that our estimate of the percent of the household work time of the mother may, in fact, be understated. We will not enter upon the delicate operation of separating such joint production and we will, therefore, content ourselves with the conservative estimate derived above.

APPENDIX B

Children in the Family and Child Spacing

The a's, b's, and c's are parameters appropriately defined as "the effective proportion of time devoted to the individual child." For the first three years of the child's preschool period, a_t is assumed to be the entire 43 percent of the mother's time. This assumption is based upon the vital statistics concerning the spacing of child-ren where the average spacing between the first and second child is two and one-half years. The median intervals between births are given in Table B-1.

TABLE B-1

Median Interval Between Births by Color: 1959*

	Interval (1955-59)
White	and the spinger states of the set
Median interval from	
First marriage of mother to	
birth of first child	16.2
Birth of first child to birth	
of second child	28.2

Nonwhite

Median interval from	
First marriage of mother to	
birth of first child	11.9
Birth of first child to birth	
of second child	23.4

*Statistical Abstract of the United States: 1966, p. 52.

For the remaining preschool years, it is assumed that the mother devotes $2l_2$ percent of her time to the child.

b coefficient reflects the combination of two factors that limit the amount of time the mother devotes to a particular child. First, once the child is in school, the amount of physical care by the mother is reduced to three hours per week for all the children (see Appendix A); and second, the mother divides her three hours among her children. The average number of children by the educational attainment of the mother is given in Table B-2. b_t is therefore determined by the two factors mentioned above for mothers with various levels of educational attainment.

TABLE B-2

Number of Children Ever Born Per 1,000 Women Ever Married, by Years of School Completed, 1960**

Years of schoo	1 completed:	
Elementary:	Less than 8 years	3,091
	8 years	2,637
High School:	1 to 3 years	2,470
C	4 years	2,074
College:	1 to 3 years	1,965
	4 years or more	1,704

**Statistical Abstract of the United States: 1966, p. 51.

In calculating the "opportunity cost" of the father's educational services, it is assumed that the father devotes one-twentieth of his time to the educational activities of his children and he spreads this time among his children. Therefore, ct is determined by this time element and the number of children according to the level of his educational attainment.

APPENDIX C

Empirical Estimation Technique and Derivation of School Resource Index

The basic data used for testing the achievement model are derived from two sources, the <u>Equality of Educational Opportunity Survey</u> and 1960 Census of Population.¹³ The EEOS data provide us with verbal achievement scores and the educational attainment of mother and father. The eight years-ofschool-completed categories for parents ranged from 0-7 years to 5+ years of college, and these were translated into income figures with the 1960 Census data relating educational attainment to income. The eight categories of educational attainment for each parent provides us with 64 cells in which all students were categorized; and the mean achievement and frequency was computed for each cell. This was the empirical foundation of the weighted multiple regressions that were performed for grades 1, 6, 9, and 12, white and nonwhite separate.

Accumulated school expenditures per student are weighed 1960 current expenditures per student14 derived from State data on expenditures and weighted across States by the number of men or women of a given level of educational attainment. Although school expenditures do vary drastically within any given State, enough differences do exist among States so that the variation is adequate to give the variable meaning and to portray differences that exist in expenditures per pupil.

TABLE C-1

Means, Standard Deviations, and Number of Observations of Variables^a in Linear Model: By Grade Level and Race

		Standard	Number of
	Mean	Deviation	Ob serva-
			tions
Grade 1	(White)		18,861
Verbal	Achievement 19.17	1.07	
Mother	4991.46	2032.44	
Father	933.22	286.79	
Grade 1	(Nonwhite)		12,453
Verbal	Achievement 16.41	.96	
Mother	2507.78	1471.45	
Father	443.99	178.80	
Grade 6	(White)		40,738
Verbal	Achievement 36.80	3.72	
Mother	7751.83	3070.00	
Father	2268.03	736.65	
School	1982,90	19.55	
Grade 6	(Nonwhite)		21,034
Verbal	Achievement 23.71	3.31	
Mother	4901.34	3070.21	
Father	1283 .87	503.59	
School	1871.14	86.95	
Grade 9	(White)		65,376
Verbal	Achievement 33.73	4.91	
Mother	8957.17	3407.64	
Father	3136.80	1045.66	
School	3228.08	29.49	
Grade 9	(Nonwhite)		28,958
Verbal	Achievement 20.71	3.16	
Mother	5561.27	3092.21	
Father	1800.53	660.62	
School	3059.01	137.07	
Grade 1	2 (White)		57,944
Verbal	Achievement 37.30	4.54	
Mother	10727.66	4118.90	
Father	4181.73	1438.98	
School	4772.35	42.67	
Grade 12	2 (Nonwhite)		22,821
Verbal	Achievement 23.60	3.77	
Mother	6626.70	3718.65	
Father	2346.75	906.67	
School	4506.88	202.70	

^aVariables include verbal achievement of student, parental contributed educational services, and school resources. *The author is a Public Policy Fellow at the Brookings Institution and Assistant Professor of Economics, The University of Notre Dame.

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1.See Hess and Shipman(7) and Jones, Lundsteen, and Michael(8), for example.

2. The opportunity cost of the parent in the labor market is not the ideal criteria for valuing parental educational services. The true measure of the value of educational services would be the price of specific parental services that influence achievement of the child. The current state of educational research, however, does not provide enough evidence to construct a set of implicit prices for the educational services of parents. Therefore, the "opportunity cost" concept, with its implicit assumptions of perfect labor market mobility of parents and perfect flows of market information, will be used to approximate the true prices of the educational services of parents.

3.See Appendix A for the complete breakdown of the activities and the number of hours per week devoted to the physical care of children.

4.See Jones, Lundsteen and Michael(8).

5.See Becker(2).

6.See Appendix B.

7.Per pupil expenditures of schools was also accumulated in the same manner as parental investments.

8.All dollar figures in constant 1966 dollars.

9. The criticisms of the shortcomings of the Coleman survey are too numerous to mention. Errors in the measurement of variables are present in the data, and results should be interpreted with care.

10.See Appendix C on data and the empirical estimation technique.

11.General Electric Company, <u>Amount of Time Spent</u> <u>in House Work</u>, Small Appliance Division Survey, Bridgeport, November 24, 1952, pp. 20-30.

12.Jean Warren, "Time Resource or Utility?", Journal of Home Economics, Vol. 49, No. 1, (January, 1957), pp. 20-22.

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14.Digest of Educational Statistics: 1963, (Washington: U.S. Government Printing Office, 1963), page 46.