Determinants of Academic Attainment in the US: a Quantile regression analysis of test scores

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Determinants of Academic Attainment in the US: a Quantile regression analysis of test scores

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Abstract

We investigate the determinants of high school students' academic attainment in maths, reading and science; focusing particularly on possible effects that ethnicity and family background may have on attainment. Using data from the NELS2000 and employing quantile regression techniques, we find two important results. First, the gaps in maths, reading and science test scores among ethnic groups vary across the conditional quantiles of the measured test scores. Specifically, Blacks and Hispanics tend to fare worse in their attainment at higher quantiles, particularly in science. Secondly, the effects of family background factors such as parental education and father's occupation also vary across quantiles of the test score distribution. The implication of these findings is that the commonly made broad distinction on whether one is from a privileged/disadvantaged ethnic and/or family background may not tell the whole story that the academic attainment discourse has to note. Interventions aimed at closing the gap in attainment between Whites and minorities may need to target higher levels of the test score distribution.

JEL Classification: I20, I21
Keywords: Educational attainment, Quantile regression, US

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1. Introduction

The educational attainment of individual students has been the focus of a large body of empirical research (Hanushek 1986; Haveman and Wolfe 1995). There are several reasons explaining the focus on educational attainment. First, there is a well established link between education and how well a person succeeds in later life. Numerous studies have pointed to the association between educational attainment and post school earnings, employment and occupational status. Second, education is one of the fundamental sources of long-term economic growth. The role of education on economic growth and development is a topic of growing interest among economists (Krueger and Lindahl 2001).

The bulk of the work related to modelling educational attainment is more or less imbedded in the human capital theory and the household production model, which were first introduced by Becker (1964) and later developed further by Leibowitz (1994), Becker and Tomes (1979, 1986), Hanushek (1979, 1986). The educational production function has become the main construct of the empirical literature to identify the relative importance of measurable educational inputs. Analogous to firm production, this framework relates contemporaneous child cognitive attainment with the educational inputs from within the family as well as from the school. Most of the previous empirical studies have estimated the education production model either by using ordinary least squares (OLS) or ordinal logit/probit model depending on the nature of data available. In these studies, a measure of educational attainment such as test score is regressed on a range of explanatory variables [1].

While estimating how educational attainment is determined, "on average", by various explanatory variables is both useful and illuminating; it is quite possible that the relationship between these explanatory variables and educational outcome of students may differ across the distribution of students' educational attainment. A natural and relatively simple way to explore such differences across the distribution of students' educational attainment is through quantile regression. By construction, quantile regression answers the question of what is the marginal effect of an explanatory variable at an arbitrary point on the conditional distribution of the dependent variable. There are questions that can be addressed more fully by focusing on the tail of the distribution rather than on the mean. In this paper, we are particularly interested in the possible differences in the effect of ethnicity and family background across the conditional quantiles of individual student's academic attainment. As such, the motivating question is whether the bottom of the distribution may systematically differ from the top. Traditional techniques that focus on the effect of explanatory variables on the mean are ill equipped to answer such questions.

A large gap in academic attainment (test scores) between white and black students in the US has been documented in previous studies (Jencks and Phillips 1998; Cook and Evans 2000; Krueger and Whitmore 2001; Fryer and Levitt 2002). The Black-White test score gap has proven to be a remarkably robust empirical regularity, although the gap has narrowed since 1970 (Cook and Evans 2000; Krueger and Whitmore 2001; Huang and Hauser 2000; Hauser and Huang 1996). Even after controlling for a wide range of covariates including family background and a measure of school inputs, a substantial gap in test score persists (Huang and Hauser 2000) [2]. Possible explanations for this gap include differences in family background and type of school attended (Brooks-Gunn *et al* 1994; Cook and Evans 2000). This thread of research, however, focused only on the differences between Black and White students at the mean, neglecting potential differences across the distribution of test scores within these groups. In addition, the possible differences between other ethnic groups, for example Hispanics and Asian, remain largely unexplored. This study attempts to fill these gaps in the existing research.

The main objectives of our paper are therefore to use the well-known US National Educational Longitudinal Survey (NELS) to be able to: i/ extend the standard empirical specification for students' educational attainment using quantile regression to explore possible differences in the explanatory power of a variety of determinants of educational attainment across the conditional distribution of students' academic attainment and ii/ introduce further ethnic dimensions into the academic attainment discourse which is dominated by distinctions between blacks and whites. The next section of the paper presents the methodology and gives a further description of the data used. Section 3 presents our estimation results and the final section concludes the paper.

2. Methodology and data

If learning is the principal goal of education, then measures of scholastic attainment, i.e. test scores, which involve a series of inputs, are the direct outcomes of the educational process. The series of inputs into the educational process come not only from the school attended but also from within the family. Hierarchical linear modelling developed by Aitken and Longford (1986) has been used to model educational attainment. This approach recognises the nested structure of the education process, which is based on the assumption that students' academic attainment are influenced by the groups to which they belong. In an alternative approach, typically taken by economists, educational attainment can be modelled within the framework of educational production developed by Hanushek (1979, 1986, 1992). This approach has been used extensively in empirical studies, most of which specify a variant of educational production model in which students' attainment (Y_t) at time T is a function of students' previous attainment (Y_{t-1}) and a vector of other covariates:

$$Y_t = f(X_t, Y_{t-1}) \tag{1}$$

As it stands equation (1) does not suggest linearity. However, applied work has often assumed linear (or log-linear) functional form. This linearity assumption implies that the effects of determinants are the same across the distribution of students' academic attainment. In our study, we follow the educational production approach but adopt the quantile regression framework first developed by Koenker and Bassett (1978) to relax the strict assumption of linearity in the effects of explanatory variables. Quantile regression allows us to examine the effects of explanatory variables at different quantiles of the test score distribution. Using this approach it is possible to estimate models for a range of conditional quantile functions, including the conditional median.

Similar to the estimation of the conditional mean regression, $E(Y \mid X = x) = X'\beta$, where β is obtained by solving $\hat{\beta} = \arg\min_{\beta \in R^p} \sum (y_i - X_i^{'}\beta)^2$, the θ^{th} quantile of the conditional distribution of y_i given X is defined as $Q_\theta(y_i \mid X) = X_i^{'}\beta(\theta),\ \theta \in (0,1)$, where $Q_\theta(y_i \mid X)$ denotes the θ^{th} quantile of the dependent variable conditioning on the vector of covariates. As noted by Koenker and Bassett (1978), the estimation of quantile regression is done by minimising the following equation:

$$\underset{\beta \in R^k}{Min} \sum_{i \in \{i: y_i \geq x_i \beta\}} \theta \mid y_i - X_i^{'}\beta \mid + \sum_{i \in \{i: y_i < x_i \beta\}} (1-\theta) \mid y_i - X'_i\ \beta \mid = \underset{\beta \in R^k}{Min} \sum_{1}^{n} \rho_\theta(u_{\theta i}) \qquad (2)$$

where y_i is the dependent variable, X is the vector of explanatory variables, β is the vector of coefficients, θ is the quantile to be estimated, and $\rho_\theta(.)$ is known as the 'check function' and defined as $\rho_\theta(u_{\theta i}) = \theta\, u_{\theta i}\ \ if\ \ u_{\theta i} \geq 0$ and $\rho_\theta(u_{\theta i}) = (1-\theta)\, u_{\theta i}$ if $u_{\theta i} < 0$. The minimisation problem can be solved by using linear programming methods (Buchinsky, 1998). The coefficient vector may differ depending on the particular quantile being estimated. This will allow us to examine (i) the differences in academic attainment between ethnic groups at different quantile of the conditional distribution of test scores after controlling for family background; and (ii) how the effect of family background may vary across quantiles of the distribution of academic attainment. By supplementing the estimation of the conditional mean functions with the estimation of the conditional quantile functions, we expect to get a more complete picture of the determination of students' academic attainment.

As stated in the previous section, the data we use in this study is from the National Educational Longitudinal Study (NELS 2000). The NELS, which began in 1988 with a cross-sectional survey of eighth graders and which continued with four follow-up interviews in 1990, 1992, 1994 and 2000, is a rich source of information on education related variables. It provides detailed family background information, information on students' academic record as well as their high school experience. One important feature of the NELS2000 is that various tests were administered to students before as well as after they enter high school. This allows us to estimate the "value added" or "growth" model of educational production function. Various measures of scholastic outcome have been used by previous studies such as test score, dropout rates and grade repetition. In this paper, we focus on standardised students' test score in Maths, Reading and Science as the dependent variables [3]. In addition to these test scores, we also use a measure of composite test score in our study.

We concentrate first on differences between ethnic groups. As noted above, previous studies have mostly investigated differences between black and white students (for example, Krueger and Whitmore 2001). In this study, ethnic origin is observed for five separate groups, namely non-Hispanic White, non-Hispanic Black, Hispanic and Asian [4]. We are therefore able to investigate possible differences in academic attainment of ethnic minority groups compared with white students, and how these differences vary across the conditional distribution of test scores.

In addition to test scores, we have an extensive set of covariates to capture the effects of family background, which are commonly found to be important in determining attainment (Haveman and Wolfe 1995). They include parental education, parental employment status, parental occupation, family size and family structure. Parental education is often found to be very important in previous studies. Covariates on family income, parental occupation and employment are used to control for the availability of financial resources in the family which has been found to be important determinant of academic attainment in previous studies (Hanushek 1992) [5]. Family size is included since there is a trade-off between quantity and quality of children in the household (Becker, 1991; Hanusheck 1992). Children are assumed to compete for scarce resources within a family, i.e. parental time, financial and other resources. Becker's theory on the quantity and quality of children (Becker 1991; Becker and Lewis 1973; Becker and Tomes 1976) suggests that the time parents allocate to each child is decreasing with the number of siblings. In addition, researchers have found that family structure plays a critical role (Mare 1980; Astone *et al* 1991; Manski *et al* 1992; Haveman *et al* 1991; Evans *et al* 1992) [6]. The presence of both parents in the family home and the financial resources contributed by them explain, at least in part, the benefit that students from intact families may reap. Findings from empirical studies tend to lend support to the above hypotheses [7].

3. Empirical results and discussion

We have estimated quantil regressions separately for males and females at the 0.1, 0.25, 0.5, 0.75 and 0.9 quantiles. The estimation results obtained are presented in Tables 2 – 7. As well as the quantile regressions, we estimate conditional mean regressions in each case to be able to compare the two and to make comparisons with findings in the literature handy. Our discussion focuses on differences between ethnic groups across the conditional distribution of maths, reading and science test scores and the effect of ethnicity and family background factors on academic attainment as measured by test scores. Table 1 reports mean values of test scores in maths, reading and science separately for males and females for each of the four ethnic groups considered. The Table shows that there are noticeable differences among ethnic groups in terms of academic attainment in the three subjects. Irrespective of gender, Black and Hispanic students perform worse than their white and Asian counterparts across the three subjects.

Our findings from the mean regressions reported in the first columns of Tables 2-7 are in line with those obtained by previous studies. Previous attainment is generally found to be significant determinant of (current) attainment in the three subjects, and this finding holds across all equations we have estimated. Controlling for a range of other factors, differences between ethnic groups remain to be statistically significant. Black students, both males and females, are found to perform worse than their White counterparts in all three subjects. Hispanic students are the next worse performers when compared with White students. This pattern holds across the three subjects for male Hispanic students but is restricted to attainment in science for females. There is some evidence that Asian students perform better than White students in maths and science but not in reading. In particular, Asian female students perform better than their White counterparts in maths and science while Asian males do so only in maths and marginally at that. In line with previous studies, we find that family background factors such as parental education and occupation are important determinants of students' academic attainment across all equations we estimate as can be gathered from the statistically significant coefficients relating to these characteristics.

The estimation results from the quantile regressions largely mimic those from the mean regressions in terms of statistical significance but do indicate marked variations in the observed effects across the quantiles we have estimated. The Black-White gap in maths, reading and science test scores are found to be statistically significant and more profound at higher quantiles of the conditional maths, reading and science test scores than at the lower quantiles. These are findings that the mean regression results reported in the first columns are unable to discern. The implication of this finding is that when designing measures that are meant to close the Black-White gap, the focus of any intervention should be targeted at higher levels of the test score distribution. This is because at lower level of the test score distribution there does not exist a statistically significant gap in attainment particularly with regards to maths and reading test scores.

Looking at the results for other ethnic groups, we find that there are some differences between the mean and quantile regression estimates. In contrast to results from the mean regressions, Asian male students are only found to perform better than their White counterparts in maths test only at the 0.9 quantile. On the other hand, Asian female students are found to perform better than their White counterparts across all quantiles as can be seen from the results at the 0.25, 0.5, 0.75 and 0.9 quantiles. In reading, Asian males are not found to perform significantly differently to their White counterparts. This is a finding that is corroborated by results from both the mean and quantile regressions, excepting the result at the median quantile. Asian female students, on the other hand, are statistically indistinguishable from their White peers in terms of attainment in reading, which is in line with findings from the mean regression. Our findings for Hispanics are similar to mean regression. In particular, Hispanic male and female students are found to be performing worse than their white counterparts around the median. In a similar fashion to Blacks, the gap between

Hispanics and Whites in science widens with the quantiles. Thus, at higher quantiles the Hispanics-White gap is the greatest and these findings hold both for males and females. In contrast, Asian males are not found to be significantly different in terms of attainment in science, while Asian females perform better than Whites particularly at higher quantiles.

With respect to the effect of family background factors, several interesting findings are worth noting. First, similar to mean regression parental education is very important. However, the effects of parental education on children's maths, reading and science test scores vary across the quantiles. With regards to maths scores, the effect of parental education is stronger for both males and females. This effect of parental education is stronger for males at higher quantiles while for females the effect appears to be stronger at lower quantiels. The same pattern emerges regarding the effect of parental education on reading scores of both males and females. In contrast, the effect of parental education on attainment in science is found to be similar for both males and females where it has stronger effects at higher quantiles.

Father's occupation is found to have significant effect on attainment for female students in the three subjects considered but the effect on male students is not found to be as important. For female students, having father in high occupational status (professional/managerial) improves their test score at the median and the surrounding 0.25 and 0.75 quantiles, but not at the other quantiles. This finding is in sharp contrast to previous studies that mostly rely on mean regression. That father's occupation is found to have no effect on students' attainment at the higher quantile may mean that for well-performing students family financial resources as captured by father's occupation may not be too importance.

4. Conclusion

In this paper, we investigate the differences in academic attainment across ethnic groups and the effect of family background factors on educational attainment. Using data from the National Educational Longitudinal Study (NELS 2000) and employing quantile regression techniques, we identify several interesting findings that previous research which relies on mean regression has not brought to light. In particular, we find that the gap in attainment in maths, reading and science tests between ethnic groups is found to vary across the conditional quantiles of the measured test scores, widening at higher quantiles. Our findings for the gap between Black and White as well as Hispanics and White students in test scores from the three subjects suggest that interventions that are meant to reduce such gaps in academic attainment among these ethnic groups should take into account the relative location of students in the test score distribution. Measures meant to close any attainment gap among ethnic groups should be targeted at higher levels of the test score distribution for that is where these gaps are at their maximum.

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Table 1: Attainment by Ethnicity

	Maths		Reading		Science	
	Males	Females	Males	Females	Males	Females
White	52.5	53.4	53.3	52	54	52
	(9.5)	(9.8)	(9.2)	(10.0)	(10.5)	(9.3)
No.	3625	3281	3661	3275	3637	4027
Black	45.7	45.3	47.8	45.2	46	46
	(9.1)	(8.8)	(9.4)	(10.1)	(8.6)	(8.0)
No.	418	357	482	355	418	559
Asian	57.1	56.8	55	53	55	52
	(9.4)	(10.2)	(9.1)	(10.2)	(10.9)	(9.7)
No.	329	32	331	324	361	384
Hispanic	46.3	47.6	48.2	46.6	48	46
	(8.7)	(9.2)	(9.0)	(9.2)	(9.2)	(7.8)
No.	635	533	635	533	606	747

Note: Standard deviations in parenthesis

Table 2: Attainment in Maths, Males

	Mean	Quantile 0.1	Quantile 0.25	Quantile 0.5	Quantile 0.75	Quantile 0.9
Previous Maths score	0.795***	0.827***	0.828***	0.821***	0.771***	0.700***
	(0.008)	(0.017)	(0.012)	(0.009)	(0.011)	(0.012)
Black	-1.181***	-0.301	-1.231***	-1.538***	-1.439***	-1.461***
	(0.272)	(0.585)	(0.420)	(0.328)	(0.416)	(0.455)
Asian	0.491*	0.662	0.306	0.407	0.415	1.033**
	(0.289)	(0.594)	(0.436)	(0.339)	(0.433)	(0.467)
Hispanic	-0.485*	-0.251	-0.550	-0.743***	-0.652*	-0.305
	(0.255)	(0.515)	(0.373)	(0.289)	(0.368)	(0.404)
Born in 1972	-3.304***	-1.870***	-2.458***	-3.463***	-4.447***	-4.992***
	(0.314)	(0.725)	(0.533)	(0.414)	(0.525)	(0.578)
Born in 1973	-1.277***	-0.820***	-0.962***	-1.285***	-1.518***	-1.372***
	(0.161)	(0.321)	(0.231)	(0.182)	(0.234)	(0.257)
Born in 1975	0.492	-0.068	-0.293	-0.076	1.122	1.426
	(0.790)	(1.426)	(1.111)	(0.880)	(1.102)	(1.117)
Parent high school	0.621**	0.497	0.173	0.374	0.381	1.387***
	(0.302)	(0.622)	(0.434)	(0.339)	(0.427)	(0.462)
Parent some college	1.044***	0.636	0.846**	0.934***	0.976**	1.739***
	(0.286)	(0.583)	(0.405)	(0.319)	(0.405)	(0.438)
Parent college	1.798***	1.745**	1.441***	1.571***	1.591***	2.254***
	(0.335)	(0.687)	(0.479)	(0.376)	(0.482)	(0.521)
Parent Masters/PhD	1.806***	1.677**	1.582***	1.176***	1.469***	2.096***
	(0.359)	(0.724)	(0.506)	(0.400)	(0.516)	(0.572)
Father non-manual	0.305	0.725	0.525*	0.149	-0.075	0.407
	(0.209)	(0.425)	(0.309)	(0.243)	(0.314)	(0.343)
Father manual	0.596***	0.705	0.564*	0.564**	0.596*	0.714**
	(0.219)	(0.439)	(0.315)	(0.246)	(0.313)	(0.336)
Father manager/professional	0.369	0.434	0.292	0.302	0.445	0.594
	(0.228)	(0.442)	(0.316)	(0.250)	(0.328)	(0.365)
Number of siblings	-0.050	-0.098	-0.098	-0.075	-0.014	0.081
	(0.052)	(0.103)	(0.074)	(0.058)	(0.074)	(0.082)
Parent-partner	-0.410**	-0.781*	-0.245	-0.285	-0.176	-0.408
	(0.226)	(0.436)	(0.314)	(0.245)	(0.310)	(0.339)
Father only	-1.299**	-1.689	-1.055	-0.535	-0.516	-1.282
	(0.551)	(1.036)	(0.751)	(0.579)	(0.737)	(0.773)
Mother only	0.029	-0.023	-0.025	-0.385	-0.053	0.159
	(0.226)	(0.467)	(0.339)	(0.266)	(0.337)	(0.360)
Catholic school	1.352***	1.166*	1.349***	1.587***	1.550***	0.962*
	(0.318)	(0.638)	(0.471)	(0.371)	(0.478)	(0.507)
Private school	0.594*	0.571	0.453	0.670*	0.502	0.203
	(0.322)	(0.615)	(0.482)	(0.381)	(0.491)	(0.527)
School size	0.000**	0.000	0.000**	0.000*	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Suburb	0.220	0.421	0.511	0.187	0.077	0.176
	(0.190)	(0.381)	(0.287)	(0.227)	(0.290)	(0.306)
Rural	0.203	0.166	0.538	0.253	0.077	0.152
	(0.234)	(0.446)	(0.348)	(0.275)	(0.355)	(0.367)
West	-0.312	-0.796*	-0.215	-0.124	-0.076	-0.437
	(0.220)	(0.432)	(0.315)	(0.247)	(0.317)	(0.352)
North Central	0.059	-0.037	0.112	-0.095	0.142	0.199
	(0.192)	(0.400)	(0.285)	(0.220)	(0.279)	(0.300)
North East	-0.173	-0.249	0.155	-0.152	-0.449	-0.426
	(0.209)	(0.430)	(0.312)	(0.245)	(0.314)	(0.339)
Constant	9.473***	1.776	4.500***	8.525***	14.304***	20.049***
	(0.591)	(1.205)	(0.875)	(0.667)	(0.822)	(0.855)
Number of observations	5094	5094	5094	5094	5094	5094

R^2/Pseudo R^2	0.81	0.52	0.58	0.59	0.57	0.53

Note: Standard errors are in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3: Attainment in Maths, Females

	Mean	Quantile 0.1	Quantile 0.25	Quantile 0.5	Quantile 0.75	Quantile 0.9
Previous Maths score	0.818***	0.819***	0.839***	0.838***	0.805***	0.776***
	(0.007)	(0.015)	(0.011)	(0.009)	(0.010)	(0.011)
Black	-0.792***	0.036	-0.599*	-1.111***	-1.051***	-0.827**
	(0.221)	(0.424)	(0.327)	(0.286)	(0.351)	(0.411)
Asian	0.804***	0.422	0.646*	0.848***	1.080***	1.067***
	(0.269)	(0.501)	(0.379)	(0.331)	(0.395)	(0.456)
Hispanic	-0.338	-0.301	-0.651**	-0.368	-0.363	-0.159
	(0.213)	(0.411)	(0.312)	(0.269)	(0.324)	(0.372)
Born in 1972	-3.544***	-2.438***	-2.437***	-3.440***	-4.328***	-5.385***
	(0.380)	(0.748)	(0.577)	(0.502)	(0.609)	(0.706)
Born in 1973	-0.981***	-0.959***	-0.778***	-0.875***	-1.142***	-0.879***
	(0.149)	(0.280)	(0.208)	(0.182)	(0.221)	(0.257)
Born in 1975	0.784	-0.108	0.578	0.417	0.743	0.326
	(0.577)	(1.210)	(0.882)	(0.777)	(0.925)	(1.102)
Parent high school	0.358	0.169	0.473	0.367	0.466	0.276
	(0.245)	(0.452)	(0.344)	(0.297)	(0.355)	(0.411)
Parent some college	1.132***	0.604	0.966***	1.047***	1.349***	1.281***
	(0.233)	(0.437)	(0.327)	(0.281)	(0.333)	(0.384)
Parent college	1.669***	1.291***	1.345***	1.665***	1.568***	1.497***
	(0.285)	(0.547)	(0.399)	(0.346)	(0.418)	(0.482)
Parent Masters/PhD	1.647***	2.272***	1.596***	1.424***	1.273***	1.103***
	(0.299)	(0.605)	(0.435)	(0.377)	(0.451)	(0.518)
Father non-manual	0.363**	0.325	0.783***	0.535**	0.128	-0.269
	(0.184)	(0.354)	(0.264)	(0.228)	(0.274)	(0.319)
Father manual	0.374**	0.348	0.649***	0.449**	0.172	-0.127
	(0.182)	(0.349)	(0.260)	(0.226)	(0.271)	(0.313)
Father Professional/manager	0.448**	0.792**	0.677**	0.393*	0.283	-0.160
	(0.191)	(0.363)	(0.266)	(0.235)	(0.287)	(0.336)
Number of siblings	-0.006	-0.079	-0.053	-0.031	0.029	0.061
	(0.041)	(0.077)	(0.060)	(0.052)	(0.061)	(0.072)
Parent-partner	-0.559***	-0.254	-0.621***	-0.379*	-0.567**	-0.610*
	(0.183)	(0.342)	(0.257)	(0.225)	(0.271)	(0.317)
Father only	0.050	0.059	0.091	0.173	0.244	-0.181
	(0.623)	(1.002)	(0.770)	(0.677)	(0.812)	(0.854)
Mother only	0.030	-0.267	-0.148	0.408	0.408	-0.201
	(0.197)	(0.376)	(0.276)	(0.240)	(0.290)	(0.342)
Catholic school	0.125	0.300	0.337	-0.148	-0.048	0.174
	(0.273)	(0.542)	(0.416)	(0.359)	(0.423)	(0.503)
Private school	-0.034	0.480	-0.138	-0.032	-0.118	-0.273
	(0.287)	(0.587)	(0.434)	(0.379)	(0.455)	(0.546)
School size	0.000**	0.000	0.000**	0.000**	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Suburb	-0.278*	-0.286	-0.176	-0.364*	-0.347	-0.270
	(0.167)	(0.327)	(0.244)	(0.212)	(0.255)	(0.302)
Rural	-0.385*	-0.337	-0.658	-0.583**	-0.245	-0.554
	(0.198)	(0.381)	(0.289)	(0.252)	(0.302)	(0.350)
West	-0.300	-0.098	-0.391	-0.308	-0.164	0.068
	(0.189)	(0.350)	(0.265)	(0.233)	(0.284)	(0.333)
North Central	-0.112	0.020	-0.264	-0.193	-0.232	0.191
	(0.162)	(0.310)	(0.234)	(0.205)	(0.246)	(0.286)
North East	-0.017	-0.103	-0.170	0.147	0.135	-0.327
	(0.183)	(0.352)	(0.263)	(0.230)	(0.278)	(0.320)
Constant	8.934***	3.612***	5.443***	8.209***	12.462***	16.719***
	(0.476)	(0.934)	(0.730)	(0.618)	(0.703)	(0.785)
Number of observations	5094	5094	5095	5094	5094	5095

R^2/Pseudo R^2	0.81	0.52	0.58	0.59	0.57	0.53

Note: Standard errors are in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 4: Attainment in reading, Males

	Mean	Quantile 0.1	Quantile 0.25	Quantile 0.5	Quantile 0.75	Quantile 0.9
Previous reading score	0.736***	0.706***	0.767***	0.782***	0.742***	0.651***
	(0.010)	(0.020)	(0.013)	(0.010)	(0.014)	(0.016)
Black	-1.300***	-0.549	-0.950**	-1.253***	-2.055***	-1.691***
	(0.343)	(0.734)	(0.472)	(0.369)	(0.546)	(0.638)
Asian	0.501	-0.635	0.480	0.800**	0.672	0.620
	(0.387)	(0.745)	(0.488)	(0.381)	(0.563)	(0.675)
Hispanic	-0.903***	-0.524	-0.821*	-1.221***	-0.623	-0.585
	(0.316)	(0.658)	(0.421)	(0.326)	(0.473)	(0.560)
Born in 1972	-2.880***	-2.196**	-2.115***	-2.474***	-4.101***	-3.705***
	(0.406)	(0.919)	(0.593)	(0.463)	(0.678)	(0.817)
Born in 1973	-1.410***	-1.698***	-1.505***	-1.403***	-1.403***	-1.147***
	(0.199)	(0.407)	(0.263)	(0.205)	(0.306)	(0.363)
Born in 1975	1.006	1.224	0.981	0.696	0.405	1.400
	(0.933)	(1.764)	(1.248)	(0.994)	(1.446)	(1.613)
Parent high school	0.582	0.228	-0.060	0.361	1.254**	1.071
	(0.358)	(0.768)	(0.489)	(0.383)	(0.565)	(0.682)
Parent some college	0.904***	0.334	0.523	0.871**	1.729***	1.415**
	(0.341)	(0.730)	(0.460)	(0.361)	(0.536)	(0.648)
Parent college	1.597***	1.228	1.343**	1.019**	2.031***	2.270***
	(0.411)	(0.872)	(0.548)	(0.426)	(0.637)	(0.772)
Parent Masters/PhD	2.096***	2.967***	1.985***	1.464***	2.080***	2.410***
	(0.425)	(0.885)	(0.570)	(0.451)	(0.681)	(0.818)
Father non-manual	0.629**	0.386	0.423	0.976***	0.546	0.180
	(0.262)	(0.551)	(0.351)	(0.274)	(0.404)	(0.483)
Father manual	0.481*	-0.125	0.092	0.639**	0.649	0.863
	(0.268)	(0.553)	(0.356)	(0.278)	(0.411)	(0.484)
Father Professional/manager	0.544**	-0.203	0.480	0.824***	0.840**	0.351
	(0.275)	(0.534)	(0.354)	(0.282)	(0.424)	(0.506)
Number of siblings	-0.029	-0.012	0.057	-0.016	0.028	-0.036
	(0.064)	(0.129)	(0.083)	(0.065)	(0.096)	(0.118)
Parent-partner	-0.422	-0.647	-0.292	-0.572**	-0.507	-0.463
	(0.266)	(0.531)	(0.353)	(0.277)	(0.409)	(0.481)
Father only	-0.617	-0.517	-0.708	-0.664	-0.685	-0.287
	(0.650)	(1.291)	(0.845)	(0.657)	(0.966)	(1.173)
Mother only	-0.452	-0.594	-0.668	-0.277	-0.663	-0.542
	(0.285)	(0.579)	(0.383)	(0.299)	(0.446)	(0.538)
Catholic school	0.768*	0.314	1.266**	1.353***	0.613	-0.376
	(0.395)	(0.808)	(0.526)	(0.422)	(0.637)	(0.753)
Private school	1.466***	2.340***	2.094***	1.359***	1.540**	0.864
	(0.415)	(0.809)	(0.539)	(0.429)	(0.647)	(0.785)
School size	0.000	0.000	0.000	0.000*	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Suburb	0.042	-0.130	0.081	0.559**	0.193	-0.080
	(0.243)	(0.490)	(0.326)	(0.257)	(0.380)	(0.453)
Rural	-0.246	-0.488	0.117	0.309	-0.205	-0.525
	(0.295)	(0.583)	(0.394)	(0.312)	(0.465)	(0.554)
West	-0.645**	-0.817	-0.780**	-0.589**	-1.036**	-0.237
	(0.278)	(0.545)	(0.352)	(0.278)	(0.416)	(0.501)
North Central	-0.235	-0.087	-0.130	-0.232	-0.520	-0.708*
	(0.237)	(0.490)	(0.319)	(0.248)	(0.363)	(0.428)
North East	-0.232	-0.018	-0.287	-0.134	-0.511	-0.579
	(0.262)	(0.550)	(0.357)	(0.277)	(0.411)	(0.484)
Constant	12.711***	7.350***	7.511***	9.946***	15.843***	24.789***
	(0.703)	(1.447)	(0.961)	(0.745)	(1.040)	(1.272)
Number of observations	4490	4490	4490	4490	4490	4490

R^2 /Pseudo R^2	0.66	0.34	0.43	0.47	0.43	0.35

Note: Standard errors are in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5: Attainment in reading, Females

	Mean	Quantile 0.1	Quantile 0.25	Quantile 0.5	Quantile 0.75	Quantile 0.9
Previous reading score	0.728***	0.732***	0.759***	0.758***	0.722***	0.671***
	(0.008)	(0.013)	(0.013)	(0.010)	(0.010)	(0.012)
Black	-0.704***	0.176	-0.395	-0.954***	-0.989***	-1.262***
	(0.271)	(0.445)	(0.426)	(0.338)	(0.335)	(0.452)
Asian	0.116	0.464	0.070	0.277	0.357	0.062
	(0.308)	(0.509)	(0.490)	(0.388)	(0.386)	(0.517)
Hispanic	-0.410	-0.005	-0.462	-0.464	-0.645**	0.131
	(0.267)	(0.411)	(0.400)	(0.318)	(0.317)	(0.416)
Born in 1972	-2.166***	-0.551	-1.658**	-2.302***	-2.907***	-2.962***
	(0.446)	(0.776)	(0.743)	(0.595)	(0.592)	(0.816)
Born in 1973	-0.909	-1.408	-0.872	-1.040	-0.591**	-0.476
	(0.185)	(0.285)	(0.272)	(0.215)	(0.214)	(0.286)
Born in 1975	0.894	1.482	-0.141	1.119	1.853	1.029
	(0.733)	(1.239)	(1.156)	(0.911)	(0.877)	(1.129)
Parent high school	0.652**	0.734	0.292	0.680*	1.060***	0.881*
	(0.301)	(0.470)	(0.444)	(0.352)	(0.348)	(0.463)
Parent some college	1.004***	1.281***	0.707*	1.016***	1.474***	1.036***
	(0.285)	(0.456)	(0.421)	(0.332)	(0.328)	(0.441)
Parent college	1.901***	2.749***	1.996***	1.806***	1.695***	1.355***
	(0.343)	(0.564)	(0.518)	(0.409)	(0.406)	(0.541)
Parent Masters/PhD	1.812***	2.994***	1.836***	1.869***	1.578***	1.120*
	(0.363)	(0.614)	(0.555)	(0.443)	(0.441)	(0.588)
Father non-manual	0.165	-0.686**	0.302	0.388	0.435	0.643*
	(0.232)	(0.356)	(0.341)	(0.270)	(0.267)	(0.365)
Father manual	0.409*	0.630*	0.824**	0.219	0.223	0.839**
	(0.225)	(0.356)	(0.337)	(0.267)	(0.265)	(0.357)
Father Professional/manager	0.598***	0.266	1.022***	0.657***	0.723***	0.489
	(0.232)	(0.366)	(0.347)	(0.279)	(0.278)	(0.372)
Number of siblings	-0.039	0.026	-0.028	-0.048	-0.081	-0.078
	(0.051)	(0.081)	(0.079)	(0.061)	(0.059)	(0.079)
Parent-partner	-0.189	-0.644*	-0.249	-0.043	-0.122	0.236
	(0.227)	(0.356)	(0.337)	(0.266)	(0.263)	(0.349)
Father only	-1.254**	-0.830	-0.199	-1.379*	-1.394*	-1.918**
	(0.616)	(1.020)	(1.003)	(0.801)	(0.792)	(0.958)
Mother only	-0.242	-0.803**	-0.133	-0.187	-0.041	0.342
	(0.254)	(0.374)	(0.362)	(0.285)	(0.281)	(0.377)
Catholic school	0.028	-0.786	-0.538	-0.171	0.727*	0.015
	(0.351)	(0.553)	(0.533)	(0.424)	(0.425)	(0.562)
Private school	1.200***	1.794***	1.501***	0.720	0.907*	0.418
	(0.335)	(0.590)	(0.556)	(0.447)	(0.446)	(0.615)
School size	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Suburb	-0.536***	-1.248***	-0.529*	-0.579**	-0.180	-0.405
	(0.208)	(0.324)	(0.313)	(0.251)	(0.251)	(0.339)
Rural	-0.495	-0.615	-0.557	-0.651**	-0.357	-0.465
	(0.249)	(0.394)	(0.378)	(0.298)	(0.296)	(0.402)
West	0.119	0.361	-0.239	0.111	0.121	-0.292
	(0.229)	(0.357)	(0.347)	(0.275)	(0.275)	(0.366)
North Central	0.182	0.631	0.006	0.201	0.183	-0.036
	(0.204)	(0.324)	(0.307)	(0.243)	(0.240)	(0.317)
North East	0.205	0.691*	-0.337	0.032	0.724***	0.085
	(0.230)	(0.359)	(0.341)	(0.272)	(0.270)	(0.365)
Constant	13.195***	6.217***	8.379**8	12.121***	16.522***	23.098***
	(0.612)	(0.943)	(0.928)	(0.735)	(0.713)	(0.924)
Number of observations	5106	5106	5106	5106	5106	5106

R^2/Pseudo R^2	0.68	0.41	0.47	0.48	0.44	0.37

Note: Standard errors are in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6: Attainment in science, Males

	Mean	Quantile 0.1	Quantile 0.25	Quantile 0.5	Quantile 0.75	Quantile 0.9
Previous science score	0.638***	0.646***	0.713***	0.682***	0.623***	0.544***
	(0.011)	(0.021)	(0.012)	(0.014)	(0.012)	(0.015)
Black	-3.720***	-2.613***	-2.740***	-3.957***	-3.744***	-4.975***
	(0.371)	(0.802)	(0.471)	(0.521)	(0.480)	(0.574)
Asian	0.401	1.124	0.214	-0.008	0.753	0.235
	(0.431)	(0.811)	(0.479)	(0.537)	(0.499)	(0.597)
Hispanic	-1.981***	-1.128	-1.904***	-2.120***	-1.778***	-1.937***
	(0.348)	(0.729)	(0.419)	(0.458)	(0.417)	(0.496)
Born in 1972	-3.657***	-1.928*	-3.118***	-3.242***	-3.769***	-4.449***
	(0.470)	(0.999)	(0.590)	(0.651)	(0.596)	(0.714)
Born in 1973	-1.035***	-1.275***	-0.637**	-1.059***	-0.975***	-0.458
	(0.222)	(0.447)	(0.256)	(0.287)	(0.263)	(0.312)
Born in 1975	1.442***	0.196	2.002	2.254	1.212	0.746
	(1.003)	(1.989)	(1.249)	(1.387)	(1.274)	(1.396)
Parent high school	1.084***	0.379	1.114**	1.096**	1.282***	1.474***
	(0.401)	(0.840)	(0.483)	(0.538)	(0.488)	(0.567)
Parent some college	1.999***	0.860	1.629***	1.929***	2.574***	2.844***
	(0.377)	(0.803)	(0.458)	(0.506)	(0.462)	(0.539)
Parent college	2.950***	1.967**	2.594***	2.987***	2.812***	3.523***
	(0.453)	(0.940)	(0.540)	(0.597)	(0.547)	(0.641)
Parent Masters/PhD	3.948***	3.086***	3.268***	3.929***	3.951***	4.599***
	(0.480)	(0.999)	(0.569)	(0.631)	(0.589)	(0.700)
Father non-manual	0.187	0.141	-0.034	0.292	0.230	0.361
	(0.293)	(0.587)	(0.346)	(0.385)	(0.353)	(0.418)
Father manual	0.798**	0.285	0.506	0.655	1.258***	1.004**
	(0.305)	(0.601)	(0.349)	(0.389)	(0.356)	(0.427)
Father Professional/manager	0.629	0.937	0.339	0.305	1.025***	0.955**
	(0.307)	(0.619)	(0.357)	(0.396)	(0.368)	(0.441)
Number of siblings	-0.053	0.008	0.057	-0.158*	-0.139*	-0.124
	(0.071)	(0.145)	(0.083)	(0.092)	(0.084)	(0.105)
Parent-partner	-0.013	0.885	0.040	-0.410	0.178	0.138
	(0.292)	(0.597)	(0.349)	(0.389)	(0.355)	(0.419)
Father only	-1.489**	0.327	-1.114	-2.182**	-1.617*	-1.795*
	(0.695)	(1.422)	(0.826)	(0.914)	(0.845)	(1.000)
Mother only	0.204	-0.053	0.470	0.116	0.067	0.636
	(0.318)	(0.638)	(0.377)	(0.422)	(0.384)	(0.447)
Catholic school	-0.013	-0.471	1.018**	0.072	-0.283	-0.175
	(0.427)	(0.890)	(0.517)	(0.587)	(0.534)	(0.629)
Private school	1.827***	2.758***	2.165***	1.440**	0.940*	0.934
	(0.455)	(0.933)	(0.543)	(0.600)	(0.544)	(0.664)
School size	0.000	0.000	0.001***	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Suburb	-0.002	-0.678	0.368	0.411	0.429	-0.363
	(0.269)	(0.547)	(0.321)	(0.360)	(0.330)	(0.384)
Rural	0.303	-0.133	0.569	0.536	0.272	-0.006
	(0.323)	(0.662)	(0.393)	(0.437)	(0.396)	(0.458)
West	-0.159	-0.957	-0.556	-0.347	0.488	0.261
	(0.302)	(0.585)	(0.345)	(0.391)	(0.362)	(0.427)
North Central	0.403	0.255	0.131	0.291	0.800	0.493
	(0.265)	(0.531)	(0.314)	(0.347)	(0.315)	(0.375)
North East	0.169	-0.934	-0.087	0.255	0.388	0.628
	(0.305)	(0.602)	(0.350)	(0.389)	(0.354)	(0.426)
Constant	17.384***	10.206***	8.463***	15.527***	22.257***	29.824***
	(0.798)	(1.568)	(0.913)	(1.031)	(0.930)	(1.122)
Number of observations	4454	4454	4454	4454	4454	4454

R^2/Pseudo R^2	0.60	0.32	0.39	0.42	0.39	0.33

Note: Standard errors are in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 7: Attainment in science, Females

	Mean	Quantile 0.1	Quantile 0.25	Quantile 0.5	Quantile 0.75	Quantile 0.9
Previous science score	0.629***	0.556***	0.634***	0.682***	0.669***	0.635***
	(0.011)	(0.017)	(0.012)	(0.014)	(0.014)	(0.017)
Black	-2.458***	-1.118**	-1.950***	-2.285***	-2.868***	-3.673***
	(0.295)	(0.529)	(0.393)	(0.445)	(0.459)	(0.574)
Asian	0.738*	-0.032	0.022	0.867*	1.122**	1.802***
	(0.394)	(0.583)	(0.448)	(0.516)	(0.525)	(0.646)
Hispanic	-1.758***	-1.626***	-1.512***	-1.597***	-2.016***	-2.070***
	(0.289)	(0.465)	(0.365)	(0.421)	(0.437)	(0.534)
Born in 1972	-1.235**	-1.716*	-1.169*	-0.970	-1.123	-1.872*
	(0.531)	(0.903)	(0.677)	(0.777)	(0.790)	(0.981)
Born in 1973	-0.898***	-0.741**	-0.712***	-0.975***	-0.959***	-1.522***
	(0.198)	(0.326)	(0.247)	(0.283)	(0.290)	(0.348)
Born in 1975	2.079**	-2.098	2.443**	3.110***	2.213*	2.468*
	(0.916)	(1.405)	(1.045)	(1.196)	(1.225)	(1.372)
Parent high school	0.601**	-0.112	-0.014	0.332	0.922*	2.047***
	(0.307)	(0.522)	(0.402)	(0.465)	(0.476)	(0.577)
Parent some college	1.499***	0.387	0.478	1.115**	1.958***	3.031***
	(0.289)	(0.502)	(0.383)	(0.440)	(0.449)	(0.539)
Parent college	3.316***	2.845***	2.176***	2.897***	3.764***	4.437***
	(0.373)	(0.624)	(0.475)	(0.542)	(0.552)	(0.670)
Parent Masters/PhD	3.732***	3.601***	2.632***	3.172***	3.607***	4.463***
	(0.400)	(0.677)	(0.517)	(0.587)	(0.593)	(0.722)
Father non-manual	0.250	0.135	0.540*	0.502	-0.146	-0.083
	(0.250)	(0.407)	(0.311)	(0.357)	(0.365)	(0.437)
Father manual	0.877***	0.713*	0.802***	0.998***	0.662*	0.843*
	(0.259)	(0.411)	(0.311)	(0.353)	(0.360)	(0.436)
Father Professional/manager	0.902***	0.179	1.096***	1.155***	1.264***	0.410
	(0.268)	(0.422)	(0.320)	(0.366)	(0.374)	(0.449)
Number of siblings	0.011	-0.027	0.052	-0.013	-0.022	0.020
	(0.057)	(0.090)	(0.069)	(0.081)	(0.082)	(0.099)
Parent-partner	-0.405	-0.411	-0.431	-0.277	-0.140	-0.296
	(0.260)	(0.405)	(0.306)	(0.352)	(0.357)	(0.438)
Father only	0.545	1.990*	1.303	0.232	-1.001	2.310*
	(0.764)	(1.208)	(0.915)	(1.060)	(1.100)	(1.310)
Mother only	-0.353	-0.490	-0.212	-0.346	-0.337	-0.673
	(0.269)	(0.441)	(0.328)	(0.375)	(0.384)	(0.475)
Catholic school	0.133	0.113	0.058	0.329	0.236	0.104
	(0.409)	(0.660)	(0.495)	(0.559)	(0.567)	(0.696)
Private school	0.696*	1.949***	1.309**	0.459	0.035	0.208
	(0.395)	(0.671)	(0.516)	(0.588)	(0.594)	(0.726)
School size	0.000	0.000	0.000	0.000	0.000*	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Suburb	-0.567**	-1.062***	-0.747***	-0.473	-0.397	-0.152
	(0.233)	(0.386)	(0.291)	(0.331)	(0.337)	(0.412)
Rural	-0.334	-1.067**	-0.560	-0.097	0.049	-0.025
	(0.279)	(0.464)	(0.348)	(0.393)	(0.394)	(0.476)
West	0.419	0.032	0.450	0.550	0.735*	0.779*
	(0.266)	(0.413)	(0.317)	(0.365)	(0.377)	(0.458)
North Central	0.968***	0.360	0.892***	1.302***	1.474***	0.691*
	(0.228)	(0.366)	(0.280)	(0.320)	(0.324)	(0.391)
North East	1.333***	1.338***	1.321***	1.315***	1.698***	1.531***
	(0.256)	(0.420)	(0.312)	(0.358)	(0.365)	(0.445)
Constant	16.090***	14.042***	12.517***	13.303***	17.043***	22.391***
	(0.694)	(1.105)	(0.831)	(0.975)	(0.989)	(1.224)
Number of observations	5063	5063	5063	5063	5063	5063

R^2/Pseudo R^2	0.58	0.28	0.34	0.39	0.39	0.37

Note: Standard errors are in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

Notes

1. The value added model suggested by Hanusheck (1979, 1992) is frequently estimated, in which a measure of educational attainment is regressed on previous attainment in addition to various explanatory variables.

2. Huang and Hauser (2000) report that differences in family background and schooling account for 45% of differences in Black-White test score.

3. Sanders (2001) argues that mathematics is usually considered more school-specific and most appropriate for studying the effect of Catholic schooling.

4. We do not include the American Indians group in our analysis due to small number of observations.

5. Other measures of family financial resources are also employed. These include 'number of years in poverty' (Haveman and Wolfe 1991) 'family ever in poverty' (Vartanian *et al* 1999) 'monthly AFDC benefit', 'monthly food stamp benefit' and 'monthly Medicaid benefit' (Ribar 1994).

6. These studies usually examine the impact of different kinds of family structure on the dropout probability. Students from intact families are found to have a greater probability of graduating from high school compared with students from non-intact families. Several models and hypotheses have been proposed for the impact of family structure. They include firstly the family dissolution effect can have a negative impact on children because of the emotional upheaval and the disturbed social relations in a family during the process of divorce. This is the crisis model of divorce often found in the sociology literature (Jonsson *et al*1997). Second, the economic deprivation hypothesis is always referred to (McLanahan 1985; Manski *et al* 1992; Astone *et al* 1991). The absence of one of the parents means loss of income and hence the financial resources needed to invest in children, thereby negatively affecting children's' attainment. This is the Becker type of argument of investment in human capital models. In addition, time constraints in single parent families are likely to have a negative effect on achievement (Astone *et al* 1991). Finally, parents' education and occupation are a fundamental source of children's aspirations. If the parent with higher education and/or social position leaves the household, the child's educational aspiration will be lower (Jonsson and Gahler 1997).

7. In an influential study Manski *et al* (1992) question the endogeneity of family structure. They examine the effect of family structure on high school graduation with data from the US National Longitudinal Study of Youth. The outcome variable is a binary variable indicating whether the respondent revived a high school diploma or GED certificate by age 20. They first employ parametric models to estimate the 'treatment' effect of family structure and then use non-parametric methods to estimate the bounds of the parametric estimates. They find that the parametric estimates are consistent with the non-parametric bounds and they conclude that family structure does have an important impact on the probability of high school graduation. Leaving in an intact family increases the probability that a child will graduate from high schools (Manski *et al* 1992).