

# Maternal education, home environments and the development of children and adolescents

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# Maternal Education, Home Environments and the Development of Children and Adolescents

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## Abstract

We study the intergenerational effects of maternal education on children's cognitive achievement, behavioral problems, grade repetition and obesity. We address the endogeneity of maternal schooling by instrumenting it with variation in schooling costs during the mother's adolescence. Using matched data from the female participants of the National Longitudinal Survey of Youth 1979 (NLSY79) and their children, we can control for mother's ability and family background factors. Our results show substantial intergenerational returns to education. For children aged 7-8, for example, our IV results indicate that an additional year of mother's schooling increases the child's performance on a standardized math test by almost 0.1 of a standard deviation, and reduces the incidence of behavioral problems. Our data set allows us to study a large array of channels which may transmit the effect of maternal education to the child, including family environment and parental investments at different ages of the child. We find that income effects, delayed childbearing, and assortative mating are likely to be important, and we show that maternal education leads to substantial differences in maternal labor supply. We investigate heterogeneity in returns, and we present results focusing both on very early stages in the child's life as well as adolescent outcomes. We discuss potential problems of weak instruments, and our results are found to be robust to changes in our specification. We discuss policy implications and relate our findings to the literature on intergenerational mobility.

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# 1 Introduction

*“... the forces that are driving the transition are leading to two different trajectories for women - with different implications for children. One trajectory - the one associated with delays in childbearing and increases in maternal employment - reflect gains in resources, while the other - the one associated with divorce and nonmarital childbearing - reflects losses. Moreover, the women with the most opportunities and resources are following the first trajectory, whereas the women with the fewest opportunities and resources are following the second.”* (McLanahan, 2004)

The above quote is from Sara McLanahan’s presidential address to the Population Association of America, in which she documents a striking increase in inequality in children’s home environments across families where mothers have different levels of education. The trends documented in these and other papers, starting with Coleman et al. (1966), are cause for great concern because the home environment is probably the best candidate for explaining inequality in child development.<sup>1</sup>

To address this problem, McLanahan (2004) ends her paper by proposing a set of changes to the welfare system. The effectiveness of such proposals is still to be assessed. However, given that home environments are rooted in the experiences of each family, they are probably difficult to change if we rely only on the welfare system. Furthermore, more direct interventions require invading family autonomy and privacy and are notoriously difficult to enforce. Therefore, one possible alternative is to target future parents in their youth, by affecting their education, before they start forming a family. In this paper we assess the potential for such a policy, by estimating the impact of maternal education on home environments and on child outcomes.

Our analysis is based on the Children of the National Longitudinal Survey of Youth of 1979, a data set with very detailed information on maternal characteristics, home environments, and child outcomes. The data allows a unified treatment of different aspects of child development across ages, including cognitive, noncognitive, and health

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<sup>1</sup>For example, Jencks and Phillips (1998), Cameron and Heckman (2001), Fryer and Levitt (2004, 2006, 2007), Carneiro, Heckman, and Masterov (2005), Todd and Wolpin (2007) and others show how differences in home environments account for a large share of the black-white test score gap.

outcomes.<sup>2</sup> Furthermore, using this single data set it is possible to estimate the impact of maternal education not only on parental characteristics like employment, income, marital status, spouse's education, age at first birth, but also on several aspects of parenting practices. Our paper provides a detailed analysis of the possible mechanisms mediating the relationship between parental education and child outcomes. The novelty of our work is in the systematic treatment of a very large range of inputs and outputs to the child development process, at different ages of the child, in a unified framework and data set. We also compare the relative roles of maternal education and cognitive ability,<sup>3</sup> and we show how the role of maternal education varies with the gender and race of the child, and with the cognitive ability of the mother.

We show that maternal education has positive impacts both on cognitive skills and behavioral problems of children, but the latter are more sustained than the former. This is perhaps because behavior is more malleable than cognition (e.g., Carneiro and Heckman (2003)). Especially among whites, there is considerable heterogeneity in these impacts, which are larger for girls, and for mothers with higher cognition. This is also a feature of many education interventions, in early childhood and beyond.

More educated mothers are more likely to work and work for longer hours, especially among blacks. Nevertheless, there is no evidence that more educated mothers do less breastfeeding, spend much less time reading to their children, or even taking them on outings. This is important because some studies suggest that maternal employment may be detrimental for child outcomes if it leads to reduced (quality) time with children.

Due to the nature of the data, this paper focuses on the effect of maternal, but not paternal, schooling. Because of assortative mating, part of the effects we find may be driven by the father's schooling through a mating effect. We interpret our estimates as total effects in that they capture both the direct effect of maternal education, and an indirect effect through father's education. Looking at the magnitudes of our estimates and those in the literature, we argue that it is unlikely that the total effect is driven

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<sup>2</sup>The dynamic aspect of cognitive and noncognitive skill formation is emphasized in the recent literature on child development, such as Carneiro and Heckman (2003), Cunha, Heckman, Lochner, and Masterov (2006), Cunha and Heckman (2007), and Todd and Wolpin (2003).

<sup>3</sup>Maternal cognitive ability is a central determinant of child's cognitive achievement. According to Todd and Wolpin (2007), racial differences in mother's cognition account for half of the minority-white test score gap among children.

exclusively by assortative mating.

The key empirical problem we face is controlling for the endogeneity of mother's schooling: factors that influence the mother's decision to obtain schooling may also affect her ability to bring up children or may relate to other environmental and genetic factors relevant to child outcomes. To deal with this issue we exploit differential changes in the direct and opportunity costs of schooling across counties and cohorts of mothers, while controlling both for permanent differences and aggregate trends as well as numerous observed characteristics such as mother's ability. The variables we use to measure the costs of education include local labor market conditions, the presence of a four year college, and college tuition at age 17, in the county where the mother resided when she was 14 years of age. These variables have previously been used as instruments for schooling by Card (1993), Kane and Rouse (1993), Currie and Moretti (2003), Cameron and Taber (2004), and Carneiro, Heckman, and Vytlačil (2010), among others. We also control for county fixed effects, to allow for permanent differences in area characteristics and in the quality of offered education, as well as for mother's cohort effects, to allow for common trends, which means that results are only driven by differential changes in local costs of education between counties and cohorts.

One potential problem is that our instruments may be weak. We therefore estimate some of our models by limited information maximum likelihood (LIML), as suggested by Staiger and Stock (1997). The resulting estimates are larger in absolute value than our original two stage least squares (TSLS) estimates and further away from the OLS coefficients, but also have larger standard errors (as predicted by Blomquist and Dahlberg (1999)).

Recently, several papers have appeared on this topic dealing with the endogeneity issue in different ways. Behrman and Rosenzweig (2002) compare the schooling attainment of children of twin mothers and twin fathers (with different levels of schooling). They find that the effect of father's education is strong and large in magnitude, but the effect of maternal education on child schooling is insignificant (see also Antonovics and Goldberger (2005); Behrman and Rosenzweig (2005)).

A set of recent papers addresses endogeneity of parental schooling in an instrumental

variable approach, exploring changes in compulsory schooling laws. This is likely to affect parental educational choice mostly at the low end of the educational distribution, and the corresponding effects need to be interpreted accordingly. Black, Devereux, and Salvanes (2005) study the effect of parental education on children's educational attainment in Norway. Regarding the effect of maternal education on child education (which is closest to this paper), their results indicate a larger effect on sons than on daughters. Although we cannot explicitly compare this effect to our study because our children are still too young to observe completed educational attainment, we also find indications that the effect of maternal education differs between girls and boys, but we do not find a uniform pattern of larger effects on boys. Oreopoulos, Page, and Stevens (2006) study grade repetition in the US as outcome, and their IV estimates are of similar magnitudes to the ones reported here. Chevalier, Harmon, O'Sullivan, and Walker (2010) study compulsory schooling laws in the UK, but emphasize the relative effect of parental education and income.<sup>4</sup> It is important to stress that, because they look at compulsory schooling, all these papers study mothers who are at the margin between taking more schooling or not at very low levels of schooling. Maurin and McNally (2008) study the effect of temporarily lower examination standards for a particular cohort in France, so that the affected individuals are those at the margin of entering higher education; the results indicate larger effects of fathers' education on child grade repetition than the effects of maternal education we find in this paper.

Currie and Moretti (2003) find that maternal education has significant effects on birthweight and gestational age. Maternal education also affects potential channels by which birth outcomes are improved such as maternal smoking, the use of prenatal care, marital status, and spouse's education. Related studies by Plug (2004), Sacerdote (2002) and Bjoerklund, Lindahl, and Plug (2006), which are based on adoptions data, compare the correlation between parental schooling and the outcomes of biological children, with the correlation between foster parents' schooling and adopted children's schooling. Adoption studies inform the debate by separating the effect of environmental and genetic factors (although their standard design can be problematic if there are

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<sup>4</sup>Chevalier (2004) and Galindo-Rueda (2003) also exploit the effect of compulsory schooling laws in the UK.

substantial interactions between genes and environments), but they do not tell us directly about the causal effect of parental schooling on child outcomes. These studies cannot distinguish between the role of parental schooling and ability in the provision of better environments.<sup>5</sup> The general sense we get from the whole literature is that the results are quite disparate and a consensus has not formed yet (see Holmlund, Lindahl, and Plug (2010)).<sup>6</sup>

The plan of the paper is as follows. In the next section we describe the data, followed by an explanation of our empirical strategy. Then we discuss our results on the impact of mother's schooling on child outcomes, followed by results on the possible mechanisms through which schooling may operate. Finally, we present a sensitivity analysis and a concluding section.

## 2 Data

We use data from the National Longitudinal Survey of Youth (NLSY79). This is a panel which follows 12,686 young men and women, aged between 15 and 22 years old in the first survey year of 1979. Surveys are conducted annually from 1979 until 1994, and every two years from 1994 onwards. We use data up to 2006.

To ensure that our sample is drawn according to pre-determined characteristics, we limit the analysis to the main cross-sectional sample and the over-sample representative of blacks and hispanics.<sup>7</sup> Attrition rates are very low (see CHRR (2002)). As we describe below, for our purpose only the females of the NLSY79 are of interest.

We measure mother's schooling as completed years of schooling.<sup>8</sup> We are interested

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<sup>5</sup>Plug (2004) finds weak effects of adoptive mother's schooling on child's schooling but large effects of father's schooling, and Bjoerklund, Lindahl, and Plug (2006) find strong effects of both adoptive father and mother's schooling. Sacerdote (2002) argues that a college educated adoptive mother is associated with a 7% increase in the probability that the adopted child graduates from college.

<sup>6</sup>Holmlund, Lindahl, and Plug (2010) replicate the differing findings based on twin studies, adoptions, and instrumental variables within one Swedish data set, suggesting that the differences cannot be fully explained by country specifics or sample characteristics.

<sup>7</sup>Apart from the main cross-sectional sample representative of the population, the NLSY79 contains an over-sample representative of blacks and hispanics, an over-sample of economically disadvantaged whites, and a sample of members of the military. In our analysis we exclude the over-sample of economically disadvantaged whites and the sample of the military.

<sup>8</sup>In doing so, we follow a large number of existing studies. Although potentially interesting, we do not address the question of how year effects compare to possible degree effects, and leave this question for future research.

in the mother’s schooling at the time when the outcome is measured.<sup>9</sup>

The data contains detailed information on family background of the mother, namely her parents’ schooling, and whether she was raised by both her biological parents. Furthermore, we know the mother’s score in the Armed Forces Qualification Test (AFQT), administered in 1980, which we use as a measure of mother’s cognitive ability.<sup>10</sup> The original AFQT score may be influenced by the amount of schooling taking up to the test date, but it is possible to estimate the effect of schooling on the test score (see Hansen, Heckman, and Mullen (2004)), and then construct a separate measure of ability.<sup>11</sup> Throughout the paper, we refer to the AFQT score as this schooling-corrected ability measure, normalized to have mean zero and standard deviation one.

In 1986, another data set, the Children of the NLSY79, was initiated. It follows the children of the female members of the NLSY79 over time and surveys each child throughout childhood and adolescence. We match the information on each child of the NLSY79 to the data of the mother. Even though the NLSY79 surveys a random sample of potential mothers, the design of the children’s sample leads to an initial oversample of children of younger mothers, until all women are old enough and have completed their child-bearing period. In 2000, the women of the NLSY79 have completed an average of 90% of their expected childbearing (CHRR, 2002). Nonetheless, as one focuses on older children, the sample eventually becomes increasingly selective.<sup>12</sup> Figure 1 in the web appendix shows the distribution of child birth cohorts in our data. The median child is born in 1986, with first and third quartiles corresponding to 1982 and 1991. The 95th percentile of the distribution is in 1998, so that almost all children in the data reach the 7-8 age bracket, which we focus on below. We also present results for

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<sup>9</sup>Occasionally, sample members do not answer this question in the year of interest. In order to include these observations, we take as the measure of schooling the maximum number of completed years reported up to the year of interest.

<sup>10</sup>In doing so, we follow a broad strand of literature which argues that the AFQT can be viewed as a proxy for cognitive skills. Exemplarily, Heckman, Stixrud, and Urzua (2006) write ‘The AFQT is a general measure of trainability and a primary criterion of eligibility for service in the armed forces. It has been used extensively as a measure of cognitive skills in the literature’ (see Heckman, Stixrud, and Urzua (2006) for corresponding references).

<sup>11</sup>Since all cohort members took the AFQT test in the same year, there is randomness in the educational attainment at the date of the test which this procedure exploits. Our measure of ability is the residual of a regression of the AFQT score on schooling attainment at the time of the test, holding (final) completed schooling constant.

<sup>12</sup>Focussing on the Wisconsin Longitudinal Study, this is investigated by de Haan and Plug (2010).



older children, and compare effects between age groups 7-8 and 12-14. We document in the sensitivity analysis that the time pattern we find in that analysis between ages 7-8 and 12-14 is not driven by increasing selectivity.

Table 1 presents an overview of the different outcomes for reference. In order to measure the child's cognitive ability we use the Peabody Individual Achievement Tests (PIAT) in math and reading, which are widely used in the literature. Behavior problems are measured using the Behavior Problems Index (BPI).<sup>13</sup> We also construct grade repetition<sup>14</sup> and child obesity indicators.

In addition, we examine potential transmission channels: mother's age at birth, an indicator variable for whether the mother is married, schooling of the mother's spouse, log of total family income (for couples, it includes both husband's and wife's incomes), number of hours the mother worked in a year, maternal aspirations of the child's educational achievement, and number of children. We take the child's age as the relevant reference point for observing the measures of interest.

One unusual feature of the data set we use is that it contains direct measures of parenting behaviors, which can also be studied as mediating channels. In particular, we look at whether: the child is taken to the museum; there is a musical instrument at home; the child gets special lessons; the mother reads to the child; newspaper and computer are available; there is adult supervision after school; and there are joint meals with both parents (Table 1).

Finally, we study children's outcomes very early in life and in adolescent years. Early measures include an indicator for low birth-weight, and the standardized score on the Motor and Social Development scale (MSD), an assessment of early motor, social and cognitive developments. We focus on ages 0 to 2. As early investments, we study smoking during pregnancy, weeks breastfeeding, use of formal child care and hours worked, and indicators for whether the mother reads to the child, how many

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<sup>13</sup>Based on data from the UK National Child Development Survey, Currie and Thomas (2001) and Carneiro, Crawford, and Goodman (2007) show that early test scores and early measures of behavioral problems are strongly associated with adolescent and adult labor market outcomes, health, and engagement in risky behaviors.

<sup>14</sup>In the NLSY79, mothers are asked whether their child ever repeated a grade in school and which grade the child repeated. We set observations to missing if the mother's set of answers to grade repetition is not consistent. Because this variable has a large number of missing observations in the earlier years of the data, we only include observations from 1996 onwards.

Table 1: Outcome variables

<i>Child outcomes (ages 7-8 and 12-14)</i>	
PIAT math	Peabody Individual Achievement Test Mathematics. Age-specific score with population mean 0 and variance 1.
PIAT read.	Peabody Individual Achievement Test Reading Comprehension. Age-specific score with population mean 0 and variance 1.
BPI	Behavior Problem Index. Gender-age specific score with population mean 0 and variance 1.
Grade repetition	Indicator for whether child has ever repeated a grade
Overweight	Indicator for whether child is overweight: Takes value 1 if child's Body Mass Index (BMI) is larger than the 95th percentile of age-gender specific distribution.
<i>Family environment (ages 7-8)</i>	
Maternal age*	Age of the mother at birth of the child (in years)
Number of children*	Total number of children ever reported by the mother.
Marital status	Indicator for whether the mother is married
Spouse's schooling	Years of schooling of mother's spouse.
Hours worked	Number of hours mother worked in past year
Log family income	Log of total annual family income (in 2002 prices, using the CPI)
Maternal aspirations	Indicator for whether mother believes that child will go to college
<i>Parental investment measures (ages 7-8 and 12-14)</i>	
Museum	Indicator for whether child is taken to museum several times or more in last year
Musical instrument	Indicator for whether there is a musical instrument child can use at home
Special lessons	Indicator for whether child gets special lessons
Mother reads	Indicator for whether mother reads to child at least three times a week
Newspaper	Indicator for whether family gets a daily newspaper
Computer	Indicator for whether child has a computer in his/her home
Adult home	Indicator: takes the value 1 if adult is present when child comes home after school, and 0 if no adult is present or if child goes somewhere else.
Joint meals	Indicator for whether child eats with both parents at least once per day.
<i>Early child outcomes (ages 0-1)</i>	
Low birthweight*	Indicator for whether child's birthweight is 5.5 lbs or less
Motor skills	Motor and social development scale (MSD), gender-age specific score standardized to mean 0 and variance 1.
<i>Early investments (ages 0-1)</i>	
Smoking during pregnancy*	Indicator for whether mother smoked in the year prior the child's birth
Weeks breastfeeding*	Number of weeks mother was breastfeeding
Formal child care	Indicator for whether formal childcare arrangements were in place for at least six months over past year
Hours worked	Number of hours mother worked in past year
Mother reads	Indicator for whether mother reads at least three times a week to the child
Books	Number of books child has
Soft toys	Number of cuddly, soft or role-playing toys child has
Outings	Indicator for whether the child gets out of the house at least four times a week
<i>Adolescent outcomes (ages 18-19)</i>	
Enrollment	Indicator for enrollment status of the young adult
Conviction	Indicator for whether the young adult has been convicted up to the age of interest
Own children	Total number of own children born to the young adult up to the age of interest

Note: Age ranges (in italics) refer to the child and define at which child age this outcome is included in the outcome regression. Not all variables vary across time, but we follow the same sample selection principle for consistency. Variables which do not vary across time are indicated by a star (\*).

books and soft toys the child has, and an indicator for whether the child gets out of the house regularly. Adolescent outcomes are measured at ages 18-19 and include school enrolment, criminal convictions and number of own children.

In the next section we discuss in detail our instrumental variable strategy. Before we do so, we explain how the instruments are constructed. The instruments for mother's schooling are average tuition in public four-year colleges<sup>15</sup> (in 1993 prices), distance to four-year colleges (an indicator whether there is a college in the county of residence), local log wage and local unemployment rate. When assigning the instruments to mothers, our approach is the following: we assign values that correspond to the year when the mother was 17, in order to be relevant for educational choices towards the end of high school; in order to avoid any potentially endogenous re-location around that period, we use maternal location at age 14. The local wage variable is county-level log wages (based on county data from the Bureau of Economic Analysis, Regional Economic Accounts, and adjusted to 2000 prices using the CPI). The state unemployment rate data comes from the BLS.<sup>16</sup> The distance variable, which is from Kling (2001), is an indicator whether in 1977 there is a four-year college in the county. Tuition measures are enrollment weighted averages of all public four-year colleges in a county, or at the state level if there is no college in the county.<sup>17</sup>

The data set contains information on a total of 4,445 white children from 1,967 white mothers, and 3,084 children from 1,220 black mothers. For some children, we observe the outcome more than once during the age range of interest. To increase precision of our estimates, we pool all available observations within the specific age range. We cluster all standard errors by cohort and county of mother's residence at age 14, thus allowing for arbitrary dependence between repeat observations from a

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<sup>15</sup>In our sensitivity analysis, we also present results where we incorporate tuition in 2-year colleges as well.

<sup>16</sup>State unemployment data is available for all states from 1976 on, and it is available for 29 states for 1973, 1974 and 1975, and therefore for some of the individuals we have to use the unemployment rate in the state of residence in 1976 (which will correspond to age 19 for those born in 1957 and age 18 for those born in 1958).

<sup>17</sup>Annual records on tuition, enrollment, and location of all public two- and four year colleges in the United States were constructed from the Department of Education's annual Higher Education General Information Survey and Integrated Postsecondary Education Data System 'Institutional Characteristics' surveys. By matching location with county of residence, we determined the presence of two-year and four-year colleges.

particular child, and between outcomes of several children from one mother, and more generally for arbitrary dependence within county-cohort cells.

Table 2 shows summary statistics for the covariates based on the sample from our PIAT math regression. There are some strong differences between the black and the

Table 2: Descriptive sample statistics

	Whites		Blacks	
	mean	st. dev.	mean	st. dev.
Mother's yrs. of schooling	13.412	[2.292]	12.740	[1.966]
Mother's AFQT (corrected)	0.406	[0.879]	-0.440	[0.786]
Grandmother's yrs. of schooling	11.813	[2.288]	10.603	[2.684]
Grandfather's yrs. of schooling	11.924	[3.136]	9.878	[3.642]
'Broken home' status	0.203	[0.402]	0.438	[0.496]
Child age (months)	95.262	[6.974]	95.900	[6.957]
Child female	0.498	[0.500]	0.501	[0.500]
College availability	0.524	[0.500]	0.601	[0.490]
Local tuition	2.113	[0.840]	1.961	[0.829]
Local unemployment	7.176	[1.769]	6.933	[1.535]
Local wages	10.270	[0.186]	10.247	[0.214]
Observations	2794		1346	

Note: The table reports sample means and (in brackets) standard deviations for covariates and instruments, based on the sample of our PIAT math outcome regression for children aged 7 to 8 (see Tables 4 and 5).

white sample. Average years of schooling are 0.67 years higher for whites. Since the AFQT score is normed to have a standard deviation of 1 in the population, the means of these two groups are more than 0.8 of a standard deviation apart. The 'broken home' status is an indicator for whether the mother grew up with both biological parents; it is more than twice as prevalent in the black sample compared to the white.

### 3 Empirical Strategy

We assume that child outcomes ( $y_i$ ) are determined by mother's years of schooling ( $S_i$ ) as well as a set of observable ( $X_i$ ) and unobservable factors. Schooling is determined by the same factors as child outcomes, and by a set of instruments ( $Z_i$ ) that reflect the measured direct and indirect costs of schooling. In interpreting the results we assume that the effects of schooling on outcomes depend on unobservables and that the IV estimates will represent Local Average Treatment Effects (LATE).<sup>18</sup>

<sup>18</sup>See Imbens and Angrist (1994).

We also allow the coefficient on maternal schooling vary with gender of the child and maternal AFQT. We define four groups depending on the sex of the child and on whether the mother is characterized by high or low ability based on her AFQT score (male-low AFQT, male-high AFQT, female-low AFQT, female-high AFQT). These four group indicators will be denoted by  $D_{ij}$ , and take the value 1 if observation  $i$  belongs to group  $j$  ( $j = 1...4$ ).  $A_i$  denotes child age. Thus our estimating equation is

$$y_i = \sum_j \beta_j D_{ij} S_i + \sum_j \gamma_{1j} D_{ij} X_{mi} + \sum_j \gamma_{2j} D_{ij} + \sum_j \gamma_{3j} D_{ij} A_i + \gamma_4 (\text{county FE}) + \gamma_5 (\text{cohort FE}) + u_i \quad (1)$$

where  $X_{mi}$  (indexed by  $m$  for maternal characteristics) is a set of conditioning characteristics and includes corrected AFQT score, grandmother's schooling, grandfather's schooling, and an indicator for mother's broken home status. 'county FE' and 'cohort FE' refer to dummy variables for the mother's birth cohort and the county where she grew up, respectively. If we did not restrict the coefficients on county and cohort fixed effects to be the same across groups this would be equivalent to running separate regressions for different groups. The corresponding first stage regressions ( $k = 1...4$ ) are:

$$S_i D_{ik} = \sum_j \delta_{1j} D_{ij} Z_i + \sum_j \delta_{2j} D_{ij} (X_{mi} * Z_i) + \sum_j \delta_{3j} D_{ij} ((\text{cohort FE}) * Z_i) + \sum_j \delta_{4j} D_{ij} X_{mi} + \sum_j \delta_{5j} D_{ij} + \sum_j \gamma_{6j} D_{ij} A_i + \delta_7 (\text{county FE}) + \delta_8 (\text{cohort FE}) + \epsilon_i \quad (2)$$

where the asterisk (\*) denotes the Kronecker product. Note that in the first term we leave out the variable 'distance to college', because in our data set this variable does not vary over time (since it is only measured in 1977). To estimate average effects across groups, we apply the Minimum Distance procedure (Rothenberg, 1971; Chamberlain, 1984) using as weights the covariance matrix of the unrestricted coefficients.<sup>19</sup>

One part of the direct cost of schooling is the amount of tuition fees a student faces

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<sup>19</sup>We provide a brief outline of this procedure in the web appendix.

and how far she has to travel to attend college. These variables have frequently been used as instruments (e.g. Kane and Rouse (1993), Card (1993), Currie and Moretti (2003), Cameron and Taber (2004), Carneiro, Heckman, and Vytlačil (2010)). Another major cost of acquiring higher education is foregone earnings. We proxy these variables by using the local unemployment rate, reflecting the speed with which someone can find work, and the local wages, as a direct measure of foregone earnings and as a determinant of expectations about future conditions. Both these variable also capture temporary shocks to family income. Therefore, it is not possible to determine a priori whether these variables have a positive or negative effect on maternal schooling, and the effect may well vary across individuals.<sup>20</sup> A key element of our approach is that we include both cohort and county fixed effects, thus relying on the way the instruments change across counties and cohorts to identify our effects. This ensures that we do not use permanent differences across cohorts or regions as source of identifying variation.

Our instruments must be correlated with mother's schooling, but must not have an independent effect on the outcome equation except through mother's schooling. We discuss these conditions in turn.

Underlying the use of geographical variation in schooling costs is the presumption that *local* variables matter for the schooling choice of the individual. In principle, individuals might move to a different location for their studies, e.g. in order to avoid high tuition costs. Still, it seems reasonable to believe that local variation matters: Moving is costly for a variety of reasons: the student is prevented from the option of living at home. Furthermore, movers may be disadvantaged in the form of higher out-of-state tuition. Currie and Moretti (2002) report evidence that the majority of students do not move to a different state to go to college (see also Hoxby (1997)).

Table 3 shows the effect of schooling cost variables on maternal schooling, where for consistency the sample of interest are white children aged 7 and 8. Similar results hold for other ages. We do not yet interact with the four group indicators as we do in the main results below. The table reports marginal effects of each regressor.<sup>21</sup> Mother's

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<sup>20</sup>See Cameron and Taber (2004) and Arkes (2010).

<sup>21</sup>The main effect of living near a college is not identified because it does not vary with time and we include county fixed effects. However we do interact it with a number of maternal background

Table 3: Maternal schooling choices and schooling costs

Dependent variable: Mother's years of schooling	
Mother's AFQT (corrected)	0.937 [0.0653]***
Grandmother's yrs. of schooling	0.158 [0.0302]***
Grandfather's yrs. of schooling	0.149 [0.024]***
'Broken home' status	-0.249 [0.144]*
Local unemployment	-0.0872 [0.0720]
Local wages	-6.771 [2.198]***
Local tuition/1000	0.409 [0.368]
Observations	2794
<i>F</i> -statistic	2.17
<i>p</i> -value	0.000***

Note: Table shows the result for a regression of maternal schooling on her characteristics and schooling cost variables, where schooling cost variables are also interacted with AFQT, grandparents' schooling, broken home indicator, and mother's birth cohort dummies. County fixed effects included. Table reports estimated marginal effects, evaluated at the mean. *F*-statistic and corresponding *p*-value refer to the joint test that all of these 47 schooling cost variables are zero. The sample is selected to be identical to the PIAT math regression in our main results, see Table 4. Standard errors, clustered by birth cohort and county are reported in brackets. \* indicates significance at 10%, \*\* at 5%, \*\*\* at 1% level. See text for details.

ability level and grandparents' schooling are important determinants of maternal education. The instruments are jointly significant at the 1% level although they are not all individually significant.

We have allowed the instruments to interact with a number of covariates reflecting maternal background and home environments. This is likely to be true in the data so our model should reflect it. Furthermore, it helps improve the overall predictive ability of the instruments. In our sensitivity analysis we show that our results are robust to very flexible specification of the outcome equations by including polynomials in maternal covariates as well as interactions between them; thus the interactions in the instrument set are not picking up non-linearities left out of the outcome equations, but allow better predictions by modeling the heterogeneity in the schooling choice.<sup>22</sup>

The second requirement for our instruments is that they should not have an independent effect on the outcome, conditional on other covariates. Thus the differential characteristics as described above.

<sup>22</sup>We have also re-estimated Table 3 for this more flexible specification, and the results are very similar to the baseline results.

changes in the costs of schooling should not predict child outcomes, conditional on covariates. By controlling for county fixed effects we avoid biases due to geographical sorting. The latter relates to individuals moving to certain counties in a way which creates a correlation between the characteristics of the region (e.g. local labor market conditions, tuition fees, etc), and outcome relevant variables such as the unobserved human capital of the person moving - the mother in our case. The fact that such sorting takes place is well established (e.g., Solon (1999), Dahl (2002)).

The second concern relates to college quality as well as local labor market conditions. If higher tuition fees are associated with higher college quality, and if higher college quality makes mothers better at child rearing, then this could bias our results. First, we use tuition from public colleges only; the link between cost and quality can be expected to be weaker in comparison to private colleges. Second, a main determinant of college quality is the quality of the students; this aspect is captured by including an ability measure of the mother, and by including family background variables. But perhaps most importantly we *do not* rely on comparing mothers who faced different tuition levels. We exploit changing tuition, which relies on the trends being common across regions, as in the differences-in-differences context. Therefore, it does not seem likely that, after controlling for mother's ability, mother's family background, and county fixed effects, endogeneity of tuition due to college quality will pose a problem. A similar argument can be made for the local labor market conditions (which should be seen as local business cycles).

## 4 Results

### 4.1 Effects on Child Outcomes

Our main outcomes are the PIAT math and reading test, the BPI, and binary for grade repetition and child obesity.<sup>23</sup> We measure these variables at both ages 7-8 and 12-14.

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<sup>23</sup>The PIAT tests and the BPI are standardized to have mean zero and variance 1 in a nationally representative sample.



### 4.1.1 White Children

Tables 4(a) and 4(b) present our main results for white children. The first line shows the estimates of the impact of maternal schooling on child outcomes for the whole sample (of white mothers), while the following four lines show how the impact of maternal schooling varies with gender of the child and AFQT of the mother. More precisely, they show the impact of maternal schooling on child outcomes for male children, female children, children of mothers with high AFQT, and children of mothers with low AFQT. The row at the bottom of the table, denoted as ‘Impact of Maternal AFQT’, shows the impact of the mother’s AFQT score on the outcome of interest. We report it to be able to compare the relative importance of maternal schooling and cognitive ability for child outcomes. Each estimate is computed as Minimum Distance estimates based on equation (1), so that all estimates reported in one column are based on one regression corresponding to equation (1). Standard errors are clustered at the county-cohort level.

OLS results indicate that one year of additional mother’s education increases mathematics standardized scores by 5% of a standard deviation at ages 7 and 8, while the IV coefficient is 10% (the difference between OLS and IV is significant at the 5% level). The results for the reading score at ages 7 and 8 are similar to those for the math score, but somewhat smaller. However, at ages 12 to 14 the effect of mother’s schooling on math scores becomes smaller in the IV results. This is essentially true for females.

Mother’s education also has strong effects on child behavioral problems (BPI) at both ages. There is an interesting pattern in these results: the effects on math decline with the age of the child, while the effect on behavior remains constant or, if anything, is increasing. Effects on reading vary across groups, with no definitive pattern. At face value it seems that a better educated mother may be able to help accelerate academic achievement, an effect that becomes weaker in the long run. However, the impact on behavior is sustained and possibly reinforced with time.

The results in columns (7) and (8) of Tables 4(a) and 4(b) examine grade repetition. A one year increase in mother’s education reduces the probability of grade repetition by almost 2 percentage points for both age groups (IV). Child obesity is not influenced

Table 4: Child outcomes – OLS and IV results: White children

(a) OLS estimates: White children

	PIAT math		PIAT read.		BPI		Grade repetition		Overweight	
	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Impact of Maternal Schooling for:										
Whole sample	0.0527 [0.0105]***	0.0342 [0.0135]**	0.0303 [0.0111]***	0.0338 [0.0122]***	-0.0716 [0.0145]***	-0.0841 [0.0138]***	-0.00404 [0.00228]*	-0.0105 [0.00318]***	-0.00641 [0.00428]	-0.00488 [0.00438]
Males	0.0500	0.0464	0.0344	0.0340	-0.0691	-0.0926	-0.00550	-0.0111	-0.0115	-0.00710
Females	0.0552	0.0266	0.0261	0.0337	-0.0754	[0.0169]***	[0.00276]**	[0.00374]***	[0.00579]**	[0.00678]
High maternal AFQT	0.0134***	[0.0159]*	[0.0140]*	[0.0151]**	[0.0196]***	[0.0177]***	[0.00262]	[0.00448]**	[0.00585]	[0.00498]
Low maternal AFQT	0.0525	0.0453	0.0426	0.0516	-0.0646	-0.0862	-0.00386	-0.00764	-0.00521	-0.00441
Impact of Maternal AFQT	0.0131***	[0.0183]***	[0.0143]***	[0.0162]***	[0.0178]***	[0.0175]***	[0.00232]*	[0.00352]**	[0.00540]	[0.00518]
Observations	0.0530	0.0218	0.0103	0.0111	-0.0847	-0.0806	-0.00653	-0.0243	-0.00869	-0.00596
Standard deviation	[0.0181]***	[0.0192]	[0.0184]	[0.0183]	[0.0242]***	[0.0226]***	[0.00625]	[0.00782]***	[0.00755]	[0.00764]
Mean	0.165	0.186	0.138	0.241	-0.0631	0.0165	-0.0170	-0.0000704	-0.0181	-0.0408
Standard deviation	[0.0386]***	[0.0466]***	[0.0426]***	[0.0499]***	[0.0564]	[0.0585]	[0.00881]*	[0.0136]	[0.0179]	[0.0181]**
Observations	2794	2745	2655	2732	2889	2968	1526	2261	2848	2941
Mean	0.356	0.319	0.511	0.0769	0.266	0.392	0.0236	0.0575	0.129	0.130
Standard deviation	0.802	0.891	0.803	0.850	0.995	0.982	0.152	0.233	0.335	0.336

(b) IV estimates: White children

	PIAT math		PIAT read.		BPI		Grade repetition		Overweight	
	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Impact of Maternal Schooling for:										
Whole sample	0.0974 [0.0250]***	0.0648 [0.0280]**	0.0582 [0.0277]**	0.0515 [0.0312]*	-0.0709 [0.0371]*	-0.0711 [0.0341]**	-0.0174 [0.00567]***	-0.0198 [0.00665]***	-0.0176 [0.0121]	-0.000302 [0.0113]
Males	0.0659	0.0735	0.0452	0.0763	-0.0480	-0.0498	-0.0182	-0.0170	-0.0159	0.0131
Females	[0.0353]*	[0.0398]*	[0.0371]	[0.0454]*	[0.0476]	[0.0463]	[0.00653]***	[0.0112]	[0.0178]	[0.0171]
High maternal AFQT	0.121	0.0595	0.0684	0.0380	-0.0912	-0.0883	-0.0161	-0.0211	-0.0189	-0.00689
Low maternal AFQT	[0.0314]**	[0.0328]*	[0.0337]**	[0.0361]	[0.0456]**	[0.0424]**	[0.00737]**	[0.00796]***	[0.0152]	[0.0129]
Impact of Maternal AFQT	0.123	0.0911	0.0750	0.0921	-0.0760	-0.0602	-0.0213	-0.0183	-0.0190	-0.00768
Observations	[0.0358]***	[0.0386]**	[0.0362]**	[0.0410]**	[0.0477]	[0.0460]	[0.00652]***	[0.00915]**	[0.0154]	[0.0147]
Mean	0.0661	0.0381	0.0340	0.00418	-0.0627	-0.0843	-0.00813	-0.0215	-0.0154	0.00912
Standard deviation	[0.0402]	[0.0389]	[0.0436]	[0.0440]	[0.0603]	[0.0505]*	[0.00954]	[0.00976]**	[0.0193]	[0.0165]
Observations	0.101	0.171	0.122	0.220	-0.0763	0.00368	0.00279	0.00632	-0.0119	-0.0481
Mean	[0.0415]**	[0.0485]**	[0.0458]***	[0.0531]***	[0.0589]	[0.0616]	[0.0120]	[0.0127]	[0.0199]	[0.0213]**
Standard deviation	2794	2745	2655	2732	2889	2968	1526	2261	2848	2941
Mean	0.356	0.319	0.511	0.0769	0.266	0.392	0.0236	0.0575	0.129	0.130
Standard deviation	0.802	0.891	0.803	0.850	0.995	0.982	0.152	0.233	0.335	0.336

Note: Table reports Minimum Distance estimates based on equation (1), see text for details. A description of the outcome variables is found in Table 1 on page 8. Standard errors reported in brackets, clustered by county-cohort. \* indicates significance at 10%, \*\* at 5%, \*\*\* at 1% level.

by maternal schooling at either age in the IV results.<sup>24</sup>

At the bottom of each table we report the impact of the maternal AFQT score on child outcomes. The cognitive ability of the mother is a strong predictor of the cognitive ability of the child. The IV results show that the effect of mother's AFQT on child's performance in math and reading is larger at 12-14 than at 7 to 8. At ages 7 to 8, each year of maternal education produces a slightly larger increase in the math score of the child than a one standard deviation in maternal AFQT, so that (very roughly) a 4 year college degree produces the same increase in math at 7 and 8 as a 4 standard deviation increase in mother's cognition (a large effect). Equally striking is the result that mother's AFQT does not predict either child's behavior or child's grade repetition, although mother's schooling is a strong determinant of both.

These results resemble the findings of Cunha and Heckman (2008), who estimate that parental background has a strong effect on the child's cognitive skill at early ages which disappears later on, and a weaker initial effect on her non-cognitive skill which becomes stronger as the child ages. In their model, cognitive and non-cognitive skills are not equally plastic across ages and they estimate that cognitive skills are less malleable than non-cognitive skills. This result has been argued to be true in other papers (e.g., Knudsen, Heckman, Cameron, and Shonkoff (2006)). Our estimates would be consistent with such a model if we interpret maternal schooling as reflecting mostly environmental effects, and maternal cognition as being at least partly related with the heritability of cognitive ability. We would expect the environment to strongly affect child behavior at all ages, but to decrease its influence on cognition as the child grows, while the role of AFQT becomes stronger with child's age. Unless there is a strong environmental component to AFQT after controlling for maternal schooling, maternal AFQT may not be strongly related with the behavior of the child (unless cognitive and non-cognitive innate traits are positively correlated in the population<sup>25</sup>).

We also present estimates for four different subsamples, defined according to the

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<sup>24</sup>To study this further, it would be interesting to look at eating habits and physical activity directly. Unfortunately, the NLSY does not contain the required variables to investigate this in more detail.

<sup>25</sup>Heckman, Stixrud, and Urzua (2006) as well as Duckworth and Seligman (2005) argue that there is little correlation between cognitive and non-cognitive traits of children and adolescents. That is not the case in the data analyzed in Carneiro, Crawford, and Goodman (2007).

gender of the child and (separately) the AFQT of the mother.<sup>26</sup> We find that at age 7-8 our estimates for math are the highest for female children and for high AFQT mothers, although they decline at ages 12-14. Results are similar for reading, with no decline in the effect for high AFQT mothers. The effect on the behavioral problems index does not decline with age and the impact is substantial and significant, at least in the overall sample. The impact of mother's education on grade repetition is also persistent across ages. Overall, at ages 7-8, results are always stronger for mother's with high AFQT. At 12-14, however, for grade repetition the results are stronger for low AFQT mothers.

Generally, the IV results for white children are higher than the OLS ones. This may seem surprising because an ability bias intuition would tell us otherwise. However, this result is common in the returns to schooling literature (Card, 1999), and also emerges in the papers by Currie and Moretti (2003) and Oreopoulos, Page, and Stevens (2006). Part of the difference can be explained by measurement error in maternal education (Card, 1999), which could bias downwards the OLS results. Beyond these common arguments the standard intuition that is valid in the fixed coefficient model no longer applies when the impacts are heterogeneous. In this case IV estimates may well exceed OLS estimates of the effect of maternal schooling on child outcomes (see, for example, Carneiro, Heckman, and Vytlacil (2010)). On the one hand, with heterogeneous effects the OLS estimates do not have a clear direction of bias; on the other hand the IV estimates, under a suitable monotonicity assumption (see Imbens and Angrist (1994)), pick up the effect on the marginal individual, which can be larger than the average effect. — A natural concern is that our instruments may be weak; we discuss this in our sensitivity analysis (Section 4.4).

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<sup>26</sup>We divide white mothers into two groups: white high AFQT mothers have a score above or equal to 0.4, while white low AFQT mothers have a score below 0.4. For blacks, we set the cutoff point at -0.25. This is done to account for the different distributions of AFQT between whites and blacks. There are two reasons why the effect of maternal education on child outcomes can vary across these two groups of mothers. First, this parameter can be a function of AFQT. Second, even within AFQT cells, this parameter can vary across observationally similar mothers. In that case the instrumental variables estimate will be an average of the effects of maternal education for the set of mothers affected by the instrument, and this set can be very different in the high and low AFQT groups, since AFQT and unobservable ability both determine the schooling decision of mothers. Unfortunately, our procedure confounds the two phenomena, but it is still of great interest especially if we can interpret it as (within each AFQT group) the effect of schooling for those mothers most likely to change schooling in response to a decrease in the costs of attending university (measured by our set of instrumental variables).

### 4.1.2 Black children

It is well documented that there are large differences in the processes of human capital accumulation of blacks and whites.<sup>27</sup> Furthermore, ethnic differences in skill formation are an important source of concern for education policies in many countries. Therefore we compare the role of maternal education for white and black children.

Tables 5(a) and 5(b) present estimates of the effect of maternal education on outcomes for black children. Results are similar to the ones for white children, with the impacts on math and reading, BPI, and grade repetition being large and significant, and the impact on obesity being imprecisely determined. There are, however, some differences. First, estimated impacts (IV) are stronger at 12-14 than at 7-8, and we do not observe the tendency of the math impact to decline. Second, in the IV estimates the impact on grade repetition for 12-14 year olds is larger for black children than for whites, although the difference is not statistically significant. For children of low AFQT mothers, a year of education reduces the probability of grade repetition by almost 3.5 percentage points (which partly mirrors differences in prevalence of grade repetition). Third, maternal AFQT is a stronger predictor of child outcomes for blacks than for whites. Fourth, the role of maternal schooling is larger for males than for females.

## 4.2 Home Environments

The impact of mothers education on child outcomes is strong in a number of dimensions. Since we do not have an explicit model of child development, we cannot firmly establish the role of these channels.<sup>28</sup> However, our results in this section paint a picture of how they may operate, and their detail makes them especially useful. The IV results for whites are reported in Table 6.<sup>29</sup> The maternal characteristics examined are maternal age at birth, educational aspirations for the child (does the mother believe whether the child will go to college), marital status, spouse's years of schooling (for those with

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<sup>27</sup>See, e.g., Currie and Thomas (1995), Jencks and Phillips (1998), Fryer and Levitt (2004), Carneiro, Heckman, and Masterov (2005), Neal (2006), Todd and Wolpin (2007).

<sup>28</sup>In a purely descriptive way, Table 23 in the web appendix shows correlations between a number of these potential channels and the outcomes PIAT math and BPI.

<sup>29</sup>In the web appendix we also report the OLS results for completeness.

Table 5: Child outcomes – OLS and IV results: Black children

(a) OLS estimates: Black children

	PIAT math		PIAT read.		BPI		Grade repetition		Overweight	
	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Impact of Maternal Schooling for:										
Whole sample	0.0891 [0.0184]***	0.0743 [0.0177]***	0.0784 [0.0175]***	0.0713 [0.0156]***	-0.0696 [0.0258]***	-0.0536 [0.0226]**	-0.00365 [0.00739]	-0.0161 [0.00702]**	0.0111 [0.00786]	0.0153 [0.00839]*
Males	0.0861 [0.0256]***	0.0815 [0.0253]***	0.0779 [0.0235]***	0.0905 [0.0215]***	-0.0778 [0.0311]**	-0.0766 [0.0281]***	0.00241 [0.00879]	-0.0248 [0.00954]***	0.00934 [0.00961]	0.0191 [0.00965]**
Females	0.0907 [0.0208]***	0.0693 [0.0216]***	0.0788 [0.0206]***	0.0547 [0.0202]***	-0.0624 [0.0300]**	-0.0346 [0.0265]	-0.0141 [0.0110]	-0.0105 [0.00818]	0.0137 [0.0113]	0.00680 [0.0136]
High maternal AFQT	0.128 [0.0299]***	0.0823 [0.0272]***	0.0918 [0.0258]***	0.0798 [0.0253]***	-0.0738 [0.0327]**	-0.0543 [0.0290]*	-0.00498 [0.00976]	-0.00580 [0.00826]	0.0227 [0.0139]	0.0157 [0.0144]
Low maternal AFQT	0.0713 [0.0213]***	0.0685 [0.0231]***	0.0694 [0.0217]***	0.0656 [0.0205]***	-0.0618 [0.0448]	-0.0527 [0.0321]	-0.00228 [0.00987]	-0.0347 [0.0105]***	0.00643 [0.00909]	0.0151 [0.0101]
Impact of Maternal AFQT	0.248 [0.0671]***	0.283 [0.0621]***	0.314 [0.0658]***	0.241 [0.0657]***	-0.0679 [0.0930]	0.0882 [0.0792]	-0.0215 [0.0262]	-0.0481 [0.0287]*	-0.0137 [0.0278]	0.0296 [0.0306]
Observations	1346	1638	1255	1629	1314	1658	470	985	1323	1699
Mean	-0.239	-0.374	0.0754	-0.561	0.456	0.459	0.0511	0.154	0.195	0.202
Standard deviation	0.850	0.875	0.814	0.844	0.992	1.000	0.220	0.361	0.396	0.402

(b) IV estimates: Black children

	PIAT math		PIAT read.		BPI		Grade repetition		Overweight	
	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Impact of Maternal Schooling for:										
Whole sample	0.0958 [0.0326]***	0.102 [0.0282]***	0.116 [0.0286]***	0.118 [0.0278]***	-0.0678 [0.0418]	-0.0814 [0.0350]**	-0.00358 [0.00712]	-0.0272 [0.0102]***	0.0113 [0.0141]	0.0145 [0.0140]
Males	0.117 [0.0404]***	0.121 [0.0370]***	0.136 [0.0363]***	0.141 [0.0393]***	-0.0703 [0.0482]	-0.106 [0.0488]**	-0.00351 [0.00791]	-0.0159 [0.0146]	0.0205 [0.0182]	0.0412 [0.0189]**
Females	0.0751 [0.0403]*	0.0843 [0.0365]**	0.0902 [0.0405]**	0.0994 [0.0359]***	-0.0640 [0.0549]	-0.0608 [0.0453]	-0.00376 [0.0106]	-0.0359 [0.0130]***	0.00279 [0.0176]	-0.0109 [0.0185]
High maternal AFQT	0.0911 [0.0466]*	0.0862 [0.0435]**	0.0702 [0.0448]	0.103 [0.0449]**	-0.100 [0.0555]*	-0.103 [0.0445]**	-0.00527 [0.00943]	-0.0231 [0.0126]*	0.0273 [0.0205]	0.0128 [0.0193]
Low maternal AFQT	0.100 [0.0439]**	0.115 [0.0392]***	0.148 [0.0372]***	0.131 [0.0399]***	-0.0316 [0.0583]	-0.0483 [0.0554]	-0.00210 [0.00897]	-0.0347 [0.0170]**	-0.00301 [0.0194]	0.0161 [0.0190]
Impact of Maternal AFQT	0.273 [0.0622]***	0.275 [0.0602]***	0.305 [0.0654]***	0.221 [0.0633]***	-0.0809 [0.0925]	0.110 [0.0804]	-0.0115 [0.0222]	-0.0365 [0.0264]	-0.0212 [0.0261]	0.0297 [0.0302]
Observations	1346	1638	1255	1629	1314	1658	470	985	1323	1699
Mean	-0.239	-0.374	0.0754	-0.561	0.456	0.459	0.0511	0.154	0.195	0.202
Standard deviation	0.850	0.875	0.814	0.844	0.992	1.000	0.220	0.361	0.396	0.402

Note: Table reports Minimum Distance estimates based on equation (1), see text for details. Standard errors in brackets, clustered by county-cohort. \* indicates significance at 10%, \*\* at 5%, \*\*\* at 1%.

Table 6: Family environment – IV results: White children

IV estimates: White children (7-8 years)							
	Maternal age	Number of children	Marital status	Spouse schooling	Hours worked	Lg family income	Maternal aspirations
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Impact of Maternal Schooling for:							
Whole sample	1.036 [0.148]***	0.0118 [0.0513]	0.0481 [0.0158]***	0.508 [0.0853]***	66.18 [35.15]*	0.144 [0.0294]***	0.0550 [0.0149]***
Males	1.178 [0.206]***	0.0230 [0.0629]	0.0534 [0.0194]***	0.509 [0.116]***	61.02 [43.18]	0.149 [0.0402]***	0.0580 [0.0208]***
Females	0.914 [0.193]***	0.00150 [0.0615]	0.0427 [0.0196]**	0.508 [0.0981]***	70.87 [41.90]*	0.139 [0.0389]***	0.0531 [0.0173]***
High maternal AFQT	0.842 [0.212]***	-0.0948 [0.0816]	0.0546 [0.0206]***	0.402 [0.126]***	23.89 [49.21]	0.145 [0.0394]***	0.0589 [0.0183]***
Low maternal AFQT	1.271 [0.235]***	0.115 [0.0799]	0.0375 [0.0269]	0.612 [0.124]***	113.0 [51.88]**	0.142 [0.0477]***	0.0484 [0.0231]**
Impact of Maternal AFQT	-0.228 [0.234]	0.0620 [0.0971]	0.00926 [0.0265]	0.0631 [0.155]	157.7 [56.60]***	0.207 [0.0518]***	0.0123 [0.0333]
Observations	4743	4743	4738	3623	4648	4109	1417
Mean	25.03	2.766	0.776	13.37	1161.6	3.740	0.773
Standard deviation	5.229	1.221	0.417	2.551	953.8	0.930	0.419

Note: Table reports Minimum Distance estimates based on equation (1), see text for details. Standard errors in brackets, clustered by county-cohort. \* indicates significance at 10%, \*\* at 5%, \*\*\* at 1%.

a spouse), number of children, hours worked, and log family income (which includes spouse’s income). All variables are measured when the child is 7 or 8.

An increase in mother’s schooling by one year leads to increases in: maternal age at birth by one year, family income by 14%, the probability of being married of 4.8%. The effect on fertility is surprisingly small.

Several economists have argued that it is important to account for the effects of assortative mating because the causal effect of maternal education on child performance may come through her ability to find an educated father for the child. Unfortunately we do not have good instruments for estimating the direct effect of spouse’s education and cannot directly assess the validity of this argument. However, we can examine the effect of maternal schooling on spouse’s schooling. Column (4) shows that an increase of one year in maternal education leads to an increase of 0.5 years of spouse’s education. If we attributed all the effects of maternal education to assortative mating we would need father’s schooling to have twice as large effects as the ones we estimate for mothers. We refer to the literature for studies which separate out the effect of maternal versus paternal schooling, and for comparability with this work we focus on IV approaches here.<sup>30</sup> Holmlund, Lindahl, and Plug (2010) are able to estimate

<sup>30</sup>As we have emphasized above, other identification strategies have come to different conclusions. An example is Behrman and Rosenzweig (2002), who estimate small or no effects of maternal education on child’s schooling, while father’s education has large and strong effects on this outcome.

separately the effect of maternal versus paternal schooling, where they treat both of these as endogenous and instrument (simultaneously) with corresponding compulsory schooling reform indicators.<sup>31</sup> Although not statistically significant, the point estimate for maternal education is consistently higher than the point estimate for father's education. Similarly, Chevalier (2004) estimates the effect of maternal and paternal schooling separately, again using compulsory schooling laws. He finds that the coefficient on maternal schooling is substantially larger than the paternal effect.<sup>32</sup> In summary, these studies do not provide evidence for the father's effect being substantially larger than the maternal effect. This leads us to conclude that although assortative mating effects may account for part of the effect we find, they are unlikely to fully drive our results.

A second argument in the literature is that maternal education can have ambiguous effects because if on one hand the child benefits from better home environments and perhaps richer investments, she will benefit of less maternal time because more educated mothers spend more time in the labor market (see e.g. Behrman and Rosenzweig (2002)). Here, we examine the effect of maternal schooling on maternal labor supply, and column (5) in Table 6 looks at the effects of maternal education on maternal employment measured in terms of annual hours worked. Annual hours worked increase by 66 hours per additional year of maternal schooling (5.7% of the mean of 1,162 hours worked per year), or roughly 1.65 weeks of full-time work per year, although the effect is imprecisely estimated. If we compared a mother with a college degree and another without, our estimates suggest that the former would work 6 more weeks per year than the latter. Cumulating over several years of childhood, these will translate into much more family resources for the mother with a college degree, but less time at home. The latter can have an offsetting effect on the former, although it depends on what kind of substitutes educated mothers can find for their time with their child.

Column (7) shows that more educated mothers are 5.5 percentage points more likely to believe that their offspring will complete college. These expectations may translate into different behavior on the side of the mother and the child.

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<sup>31</sup>The outcome is years of schooling, see Table 3.C in Holmlund, Lindahl, and Plug (2010).

<sup>32</sup>See Tables 4A and 4B in Chevalier (2004). When the sample is limited to natural parents only, maternal and paternal schooling is found to be of equal magnitude.



The estimates presented in Table 6 are fairly similar for boys and girls, and for children of mothers with high and low levels of AFQT. There are only a few cases of interesting differences across groups. In particular, the effect of maternal education on maternal aspirations and marital status are smaller for low AFQT mothers than for other groups, which may be one of the reasons why we found weak effects on child outcomes for this group of mothers. Labor supply and assortative mating effects are particularly strong for low AFQT mothers (but not for family income effects).

One feature of the data set is the wealth of information on direct measures of home environments and parental investments, as reported in Table 7. For white children, an

Table 7: Investments – IV results: White children

	IV estimates: White children							
	Museum 7-8 yrs	Musical Instr. 7-8 yrs	Special lesson 7-8 yrs	Mother reads 7-8 yrs	Newspaper 7-8 yrs	Computer 12-14 yrs	Adult home 12-14 yrs	Joint meals 12-14 yrs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Impact of Maternal Schooling for:								
Whole sample	0.00888 [0.0164]	0.0434 [0.0172]**	0.0621 [0.0147]***	0.0325 [0.0153]**	-0.0155 [0.0175]	0.0570 [0.0146]***	0.0257 [0.0157]	-0.0161 [0.0182]
Males	0.0330 [0.0232]	0.0513 [0.0224]**	0.0885 [0.0203]***	0.0350 [0.0227]	-0.0186 [0.0238]	0.0476 [0.0205]**	0.0109 [0.0208]	-0.0149 [0.0241]
Females	-0.0108 [0.0211]	0.0368 [0.0209]*	0.0437 [0.0176]**	0.0308 [0.0190]	-0.0133 [0.0208]	0.0644 [0.0185]***	0.0395 [0.0202]*	-0.0170 [0.0224]
High maternal AFQT	0.00910 [0.0215]	0.0613 [0.0231]***	0.0601 [0.0181]***	0.0310 [0.0208]	-0.0145 [0.0235]	0.0471 [0.0186]**	0.0189 [0.0210]	-0.0394 [0.0235]*
Low maternal AFQT	0.00856 [0.0264]	0.0186 [0.0274]	0.0662 [0.0261]**	0.0347 [0.0254]	-0.0169 [0.0288]	0.0742 [0.0246]***	0.0333 [0.0222]	0.0139 [0.0263]
Impact of Maternal AFQT	0.0137 [0.0282]	0.0289 [0.0324]	-0.000313 [0.0274]	-0.0166 [0.0284]	0.0746 [0.0300]**	0.0248 [0.0314]	-0.0690 [0.0299]**	0.00344 [0.0328]
Observations	2976	2975	2974	2981	2977	1681	2682	2975
Mean	0.419	0.539	0.685	0.495	0.531	0.681	0.681	0.560
Standard deviation	0.494	0.499	0.465	0.500	0.508	0.466	0.466	0.496

Note: Table reports Minimum Distance estimates based on equation (1), see text for details. Standard errors in brackets, clustered by county-cohort. \* indicates significance at 10%, \*\* at 5%, \*\*\* at 1%.

increase in mother’s schooling by one year leads to increases in the probabilities that: there is a musical instrument in the home by 4.3%; there is a computer in the home by 5.7%; a child takes special lessons by 6.2%. Each extra year of schooling also means that mothers are 3.25% more likely to read to their child at least three times a week. There is no evidence that maternal education affects the amount of newspapers in the home, adult supervision out of school, and time spent with the child in a museum or sharing meals. Notice that more educated mothers do not seem to spend less time in activities with their children, even though they spend more time working. This pattern emerges throughout the paper, and we will comment on it with detail when we examine the child’s early years.

Testing for gender differences in investments in Table 7, we have not been able to reject the hypothesis that the effect is the same for boys and girls. The only exception is in column (3), special lessons, where the difference is significant at 10%.

The results for black mothers are slightly different, and they are shown in Tables 8 and 9. Relatively to white mothers, education not only affects maternal age at

Table 8: Family environment – IV results: Black children

IV estimates: Black children (7-8 years)							
	Maternal age	Number of children	Marital status	Spouse schooling	Hours worked	Lg family income	Maternal aspirations
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Impact of Maternal Schooling for:							
Whole sample	0.899 [0.160]***	-0.320 [0.0626]***	0.0646 [0.0194]***	0.564 [0.0704]***	192.8 [32.40]***	0.175 [0.0314]***	0.0457 [0.0153]***
Males	1.040 [0.207]***	-0.345 [0.0724]***	0.0801 [0.0235]***	0.541 [0.0841]***	225.9 [48.86]***	0.230 [0.0375]***	0.0422 [0.0184]**
Females	0.763 [0.204]***	-0.290 [0.0763]***	0.0475 [0.0243]*	0.587 [0.0839]***	174.2 [38.38]***	0.0999 [0.0423]**	0.0507 [0.0211]**
High maternal AFQT	0.885 [0.237]***	-0.264 [0.0875]***	0.0588 [0.0307]*	0.535 [0.111]***	146.0 [44.99]***	0.249 [0.0505]***	0.0158 [0.0219]
Low maternal AFQT	0.909 [0.207]***	-0.370 [0.0830]***	0.0679 [0.0238]***	0.586 [0.0956]***	242.7 [46.43]***	0.132 [0.0390]***	0.0702 [0.0200]***
Impact of Maternal AFQT	-0.0128 [0.296]	0.0913 [0.107]	0.0673 [0.0393]*	-0.109 [0.199]	120.3 [73.51]	0.213 [0.0737]***	0.0954 [0.0474]**
Observations	2735	2735	2733	991	2710	2203	468
Mean	22.47	3.105	0.382	12.73	1150.4	3.033	0.660
Standard deviation	4.953	1.419	0.486	2.098	995.5	0.886	0.474

Note: Table reports Minimum Distance estimates based on equation (1), see text for details. Standard errors in brackets, clustered by county-cohort. \* indicates significance at 10%, \*\* at 5%, \*\*\* at 1%.

Table 9: Investments – IV results: Black children

IV estimates: Black children								
	Museum 7-8 yrs	Musical Instr. 7-8 yrs	Special lesson 7-8 yrs	Mother reads 7-8 yrs	Newspaper 7-8 yrs	Computer 12-14 yrs	Adult home 12-14 yrs	Joint meals 12-14 yrs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Impact of Maternal Schooling for:								
Whole sample	0.0314 [0.0185]*	0.00958 [0.0192]	0.0951 [0.0187]***	0.0499 [0.0175]***	-0.00982 [0.0178]	0.0648 [0.0172]***	-0.0377 [0.0159]**	0.0267 [0.0164]
Males	0.0275 [0.0226]	-0.00539 [0.0256]	0.0947 [0.0245]***	0.0557 [0.0206]***	-0.0125 [0.0229]	0.0534 [0.0235]**	-0.0355 [0.0218]	0.0298 [0.0218]
Females	0.0369 [0.0262]	0.0223 [0.0240]	0.0954 [0.0237]***	0.0408 [0.0242]*	-0.00626 [0.0260]	0.0759 [0.0233]***	-0.0396 [0.0208]*	0.0237 [0.0215]
High maternal AFQT	0.0112 [0.0279]	0.00667 [0.0304]	0.130 [0.0257]***	0.0535 [0.0243]**	-0.00534 [0.0251]	0.0881 [0.0266]***	-0.0144 [0.0235]	0.0544 [0.0242]**
Low maternal AFQT	0.0448 [0.0231]*	0.0114 [0.0243]	0.0601 [0.0258]**	0.0473 [0.0214]**	-0.0140 [0.0241]	0.0467 [0.0232]**	-0.0576 [0.0217]***	0.00113 [0.0232]
Impact of Maternal AFQT	0.000774 [0.0381]	0.0400 [0.0419]	0.0103 [0.0392]	-0.0625 [0.0383]	0.107 [0.0430]**	0.0816 [0.0448]*	0.00170 [0.0404]	-0.0782 [0.0415]*
Observations	1389	1388	1388	1391	1390	906	1549	1650
Mean	0.405	0.352	0.453	0.331	0.413	0.352	0.701	0.316
Standard deviation	0.491	0.478	0.498	0.471	0.493	0.478	0.458	0.465

Note: Table reports Minimum Distance estimates based on equation (1), see text for details. Standard errors in brackets, clustered by county-cohort. \* indicates significance at 10%, \*\* at 5%, \*\*\* at 1%.

birth, aspirations, marital status, spouse's schooling and income, but it also has large effects on fertility and employment. Each additional four years in school (a four year

university degree) decreases the number of children born to each woman by 1.3, and increase maternal employment by over 750 hours (or roughly 19 weeks) per year. The effects of education on income are especially large for high AFQT mothers, while the effects of education on employment and fertility are stronger for low AFQT mothers.

It is remarkable that each year of maternal schooling among blacks increases the proportion of children going to a museum at least several times per year by 3.1%, and the proportion of children who are read to at least three times a week by 5% (these are time intensive activities). Part of this may be due to the fact that more educated black mothers have less children to spend their time with. However, an extra year of maternal education also makes it 3.8% less likely that black children have adult supervision when they arrive home after school.

In summary, there exists strong evidence that maternal education affects home environments and child outcomes. The size of several of our estimates in this section is large, and suggests that we should seriously look at education policy as a way of improving the home environments of future generations of children. Educated mothers provide better surroundings for their children by postponing and decreasing childbearing, by increasing family resources, and by assortative mating. There is also strong evidence that educated mothers invest more in their children. However, educated mothers also spend longer periods outside the home working and earning. Still, whatever the negative consequences of spending time away from the children may be, they are outweighed by the positive effects. With the exception of adult supervision for black children, more educated mothers do not spend less time with their children, either because they have less children, or less leisure time. If anything, our results indicate that the opposite is true.

At this point it is useful to compare our estimates of the effect of maternal education to those of other childhood interventions. The large class size reduction of the STAR experiment (a reduction from 22 to 15 pupils per class, studied by Krueger (1999)) yielded test score gains of 0.2 standard deviations, an equivalent of two years of maternal schooling. Dahl and Lochner (2006) estimate that a \$1,000 increase in family income improves performance on the math test score by 2.1% of a standard

deviation (3.6% for reading). Currie and Thomas (1995) estimate that participation in Head Start increases performance in the PPVT vocabulary test by almost 6 percentile points (which is about 20 to 25% of a standard deviation). Bernal and Keane (2006) find that additional formal child care does not improve the average child test score performance, but may be beneficial for children of poorly educated mothers. Aizer (2004) estimates that adult supervision after school reduces the probability of a child engaging in risky behavior by about 7 percentage points. Dustmann and Schönberg (2007) find that increasing paid maternity leave does not significantly improve long-term child outcomes, although Carneiro, Salvanes, and Løken (2010) find large effects on high school dropout rates. Our claim is that, although the nature of the different interventions differs quite a lot, the effects of maternal education are large when compared to those of other interventions. If the objective is to increase children's outcomes, additional maternal education is a serious competitor to the other types of interventions. Of course, in doing this kind of comparison, it is important to keep in mind that each of the interventions have different costs and may affect children along a variety of dimensions, and comparisons become difficult when trade-offs between different objectives are involved. One particular cost of raising child outcomes through maternal education is that it may involve a substantial time lag between the introduction of the policy and the time the children have grown up.

Furthermore, when interpreting the findings to predict effects of future policies, one needs to keep in mind that the introduction of large-scale policies may be accompanied by general equilibrium effects, which may partially offset the effects we estimate. This qualification applies in particular to the mating channel; if a policy was to raise the schooling of every (potential) mother, without affecting the schooling of (potential) fathers, there could not be aggregate gains in spouse's schooling (this is particularly important if most of the effects of maternal schooling on child development came through assortative mating, an issue which we discuss towards the beginning of this section).

## 4.3 Early Childhood and Young Adulthood

In this section we investigate two issues. First, which of these effects are visible at earlier ages of the child? This question is particularly interesting given the recent academic and policy emphasis on the importance of the early years. Second, is there any evidence of effects of maternal schooling on environments and behavior during adolescence and young adulthood, when behavioral anomalies such as engagement in criminal activities, early dropping out of school, or early childbearing, may be the source of long run problems? Ideally, we would like to follow individuals well into their adult lives, but unfortunately this is not yet possible with this sample.

### 4.3.1 Early Childhood

Here we present estimates of the effect of maternal schooling on the probability of the child having low birth-weight (weighing less than 5.5 pounds at birth), and the score on the MSD scale, which assesses the motor and social skills development, both for children up to 24 months. Results are shown for whites and blacks in Table 10.

Table 10: Early outcomes – IV results

	IV estimates: Children 0-1 years			
	Whites		Blacks	
	Low birthweight	MSD	Low birthweight	MSD
	(1)	(2)	(3)	(4)
Impact of Maternal Schooling for:				
Whole sample	-0.00274 [0.00684]	-0.0802 [0.0322]**	-0.0129 [0.0126]	0.0883 [0.0436]**
Males	-0.00360 [0.0102]	-0.0816 [0.0415]**	-0.0107 [0.0154]	0.0618 [0.0496]
Females	-0.00184 [0.0105]	-0.0785 [0.0437]*	-0.0165 [0.0193]	0.151 [0.0707]**
High maternal AFQT	-0.00800 [0.0101]	-0.0588 [0.0394]	0.00870 [0.0162]	0.0164 [0.0579]
Low maternal AFQT	0.00335 [0.0110]	-0.124 [0.0572]**	-0.0372 [0.0170]**	0.163 [0.0589]***
Impact of Maternal AFQT	-0.00860 [0.0130]	0.0208 [0.0657]	-0.000801 [0.0245]	-0.254 [0.120]**
Observations	5590	2145	2811	787
Mean	0.0649	-0.0390	0.130	0.181
Standard deviation	0.246	0.994	0.337	1.215

Note: Table reports Minimum Distance estimates based on equation (1), see text for details. Standard errors in brackets, clustered by county-cohort. \* indicates significance at 10%, \*\* at 5%, \*\*\* at 1%.

Currie and Moretti (2003) find that one extra year of maternal education reduces the probability that a child is born with low birth-weight by 1 percentage point. Our estimates for whites are lower and insignificant, whether we use OLS or IV, although

Table 11: Early channels – IV results: white children

	IV estimates: White children 0-1 years							
	Smoking d. pregnancy	Weeks breastfeeding	Formal child care	Hours worked	Mother reads	Book	Soft toys	Outings
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Impact of Maternal Schooling for:								
Whole sample	-0.0644 [0.0165]***	1.943 [0.809]**	0.0135 [0.00677]**	98.69 [28.68]***	0.00636 [0.0135]	0.0646 [0.0279]**	-0.210 [0.395]	-0.000516 [0.0135]
Males	-0.0774 [0.0227]***	1.888 [0.995]*	0.00578 [0.00987]	116.5 [39.01]***	-0.000237 [0.0183]	0.0531 [0.0413]	-0.482 [0.495]	-0.0142 [0.0184]
Females	-0.0536 [0.0209]**	2.005 [1.043]*	0.0210 [0.00974]**	83.46 [36.51]**	0.0139 [0.0196]	0.0750 [0.0392]*	0.177 [0.580]	0.0121 [0.0177]
High maternal AFQT	-0.0531 [0.0227]**	2.101 [1.033]**	0.0169 [0.0112]	106.3 [37.82]***	-0.00545 [0.0177]	0.0214 [0.0373]	-0.314 [0.528]	0.00593 [0.0164]
Low maternal AFQT	-0.0790 [0.0262]***	1.679 [1.342]	0.0117 [0.00834]	87.59 [45.94]*	0.0252 [0.0227]	0.131 [0.0473]***	-0.0651 [0.631]	-0.0149 [0.0249]
Impact of Maternal AFQT	-0.0811 [0.0290]***	0.643 [1.378]	0.0196 [0.0101]*	85.48 [41.41]**	0.0494 [0.0280]*	0.150 [0.0572]***	2.496 [0.722]***	0.0329 [0.0260]
Observations	5649	3234	4888	5990	2403	2427	2387	2425
Mean	0.351	22.23	0.0671	928.0	0.610	3.251	16.66	0.752
Standard deviation	0.477	21.98	0.250	881.0	0.488	1.059	12.42	0.432

Note: Table reports Minimum Distance estimates based on equation (1), see text for details. Standard errors in brackets, clustered by county-cohort. \* indicates significance at 10%, \*\* at 5%, \*\*\* at 1%.

we have a much smaller sample than Currie and Moretti (2003). Results are only statistically strong for black mothers with low AFQT scores, for whom the coefficient is -0.036 (the incidence of low birth-weight is 13% in the sample of blacks).

Looking at the relationship between maternal education and early motor and social skills of the child a new picture emerges. For whites, our estimates are negative, and especially important for low ability mothers. This is the first and only instance in this paper where increases in maternal schooling are shown not to be good for children, perhaps because of increased maternal employment and less time with the child.

Table 11 presents the results for early home environments of whites, where the following outcomes are considered: smoking in the year prior to the birth of the child, weeks of breastfeeding, use of formal child care arrangements, annual hours worked by the mother, whether the child is read to, how many books and soft toys the child has, and whether the child is taken on outings regularly.

The two health inputs, (not) smoking and breastfeeding, are strongly affected by maternal schooling. Notice also that the effect on maternal hours worked is much larger when measured during the child's early years than later on (as we saw in Table 6). At the same time, the increase in formal child care is modest and only statistically strong for girls. The strong increase in hours worked that results from additional education is not accompanied by a strong increase in formal child-care, raising the question of

Table 12: Early channels – IV results: Black children

IV estimates: Black children 0-1 years								
	Smoking d. pregnancy	Weeks breastfeeding	Formal child care	Hours worked	Mother reads	Book	Soft toys	Outings
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Impact of Maternal Schooling for:								
Whole sample	-0.0454 [0.0181]**	0.745 [0.660]	0.0189 [0.00758]**	189.6 [28.08]***	0.0501 [0.0199]**	0.131 [0.0472]***	-0.111 [0.411]	0.0136 [0.0159]
Males	-0.0218 [0.0228]	0.541 [0.844]	0.0166 [0.00943]*	181.5 [35.75]***	0.0580 [0.0234]**	0.148 [0.0549]***	0.478 [0.525]	0.0185 [0.0206]
Females	-0.0710 [0.0236]***	0.974 [0.885]	0.0224 [0.0114]**	199.0 [38.22]***	0.0382 [0.0275]	0.105 [0.0631]*	-0.469 [0.457]	0.00815 [0.0218]
High maternal AFQT	-0.0402 [0.0245]	-0.920 [1.011]	0.0347 [0.0145]**	171.5 [39.27]***	0.0524 [0.0282]*	0.0863 [0.0605]	-0.117 [0.477]	-0.00573 [0.0194]
Low maternal AFQT	-0.0516 [0.0268]*	1.654 [0.781]**	0.0135 [0.00870]	209.5 [41.26]***	0.0482 [0.0262]*	0.172 [0.0589]***	-0.100 [0.569]	0.0431 [0.0233]*
Impact of Maternal AFQT	0.0114 [0.0354]	1.820 [2.459]	0.00912 [0.0143]	141.7 [59.15]**	0.0160 [0.0431]	0.210 [0.0902]**	-1.128 [0.849]	0.0362 [0.0357]
Observations	2803	632	2260	2977	906	909	901	909
Mean	0.295	18.09	0.0695	770.1	0.374	2.353	11.18	0.703
Standard deviation	0.456	19.26	0.254	886.6	0.484	1.193	10.04	0.457

Note: Table reports Minimum Distance estimates based on equation (1), see text for details. Standard errors in brackets, clustered by county-cohort. \* indicates significance at 10%, \*\* at 5%, \*\*\* at 1%.

how these children are cared for. This could be seen as support to the argument that more educated mothers spend more time working, with detrimental effects on child development. Still, even if this is true, children seem to recover, so that BPI and grade repetition at 12 and 14 are lower when maternal education is higher. Finally, there is no evidence that, even though they work more, more educated mothers spend less time breastfeeding, reading to their children, or taking them on outings. This is consistent with recent findings from time diary studies summarized in Blau and Currie (2010): mothers who work more do not spend less time with their children; instead, they have less leisure. Notice also that young children of educated mothers have more books than other children, especially if their mothers have low cognitive ability.

In summary, it is difficult to make the case that the large increase in employment of white mothers that results from additional education has detrimental effects on children. There may be some delays in their motor and social development, especially for low AFQT mothers, but they do not appear to have any long term undesirable consequences. In fact, it is for low AFQT mothers that maternal education has the largest positive effects on home environments.

For black families this picture is even more evident. The impacts of maternal education on birth-weight and motor and social development are positive and large, especially for low ability mothers (columns (3) and (4) of Table 10). An additional

year of education leads to about 190 extra hours of work, but also more regular use of formal child care arrangements, more time reading to the child, and more children’s books in the home (Table 12). Breastfeeding is prolonged for low AFQT mothers.

The estimates displayed in Tables 11 and 12 tell a clear and important story: improvements in maternal schooling promote much better home environments during the early years of the child; although more educated mothers work more, they do not spend less quality time with their children, and if anything the opposite is true; it is striking that for many outcomes, for both black and white mothers, it is for low ability mothers that education has the largest impact on early home environments.

### 4.3.2 Young Adulthood

Finally, we examine engagement in some risky behaviors in late adolescence: early dropping out of school, early childbearing, and criminal activity. It is important to keep in mind that many children of the NLSY79 cohort members have not yet reached adulthood. Thus, the children we observe in this age range are mainly from the early cohorts and from mothers with very low birth ages, and the sample size is smaller than for the younger cohorts. Still, at the very least, the following demonstrates that the effect of maternal education follows the children into adulthood.

Table 13: Young adults – IV results

	IV estimates: Young adults (18-19 years)					
	White			Black		
	Enrollment	Conviction	Own children	Enrollment	Conviction	Own children
	(1)	(2)	(3)	(4)	(5)	(6)
Impact of Maternal Schooling for:						
Whole sample	0.0193 [0.0160]	0.00625 [0.0115]	-0.00952 [0.00914]	0.0267 [0.0174]	-0.0182 [0.0127]	-0.0368 [0.0148]**
Males	0.00823 [0.0208]	0.0116 [0.0180]	-0.000897 [0.0110]	0.0128 [0.0245]	-0.0776 [0.0215]***	-0.0141 [0.0177]
Females	0.0321 [0.0221]	0.00285 [0.0145]	-0.0253 [0.0145]*	0.0407 [0.0245]*	0.00569 [0.0145]	-0.0746 [0.0218]***
High maternal AFQT	0.0186 [0.0201]	0.0161 [0.0144]	-0.0105 [0.0101]	0.0105 [0.0255]	-0.0449 [0.0181]**	-0.0468 [0.0194]**
Low maternal AFQT	0.0203 [0.0234]	-0.00862 [0.0174]	-0.00699 [0.0142]	0.0415 [0.0244]*	0.0000641 [0.0155]	-0.0249 [0.0211]
Impact of Maternal AFQT	0.0162 [0.0302]	-0.0335 [0.0203]*	-0.00132 [0.0160]	-0.0586 [0.0376]	-0.0272 [0.0232]	-0.000661 [0.0312]
Observations	1597	1672	1494	1027	1155	988
Mean	0.700	0.149	0.0703	0.691	0.130	0.148
Standard deviation	0.458	0.356	0.266	0.462	0.336	0.396

Note: Table reports Minimum Distance estimates based on equation (1), see text for details. Standard errors in brackets, clustered by county-cohort. \* indicates significance at 10%, \*\* at 5%, \*\*\* at 1%.

Table 13 present estimates of the effect of maternal schooling on several outcomes:



a dummy for school enrollment, a dummy for convictions, and the number of own children, all at ages 18 and 19. Among whites, the results are generally not significant. For blacks, the decrease in the conviction rate is notable for boys and children of high ability mothers, and so is the decrease in fertility, especially for girls.

For outcomes during young adulthood to be observed in our data set, children need to be born when the mother is still relatively young, so that the sample for our early adolescence outcomes may be different from the sample corresponding to outcomes we measure at younger ages. To examine this in more detail, Table 24 in the web appendix compares maternal background characteristics between, on the one hand, the children included in the young adult sample and, on the other hand, those included in our main sample of 7-8 year olds. There are notable differences between these two samples, for example, average maternal age at birth is about three years apart. There are also differences in mean maternal schooling, AFQT, and grandparents' schooling. The differences are much more pronounced in the white sample than in the black sample, and this is what we would expect given the substantially lower mean maternal age at birth in the sample of blacks. We have also re-estimated our main set of outcomes at ages 7-8, but restricted the sample to those children who contribute at least one observation to the young adult sample. The results are shown in Table 25 in the web appendix. For some outcomes we find notable differences in the estimated effects between the two samples, and this supports the view that the sample we see at adolescent ages is a particular subsample of all children and needs to be interpreted accordingly. Nonetheless, the analysis on adolescent outcomes above suggests that at least for part of this population, we see long-run effects of maternal education.

#### **4.4 Sensitivity Analysis**

In this section we examine the sensitivity of our main results, presented in Section 4.1 above. An important concern in this paper is with the potential weakness of the instruments (although the  $p$ -values of the instruments in the first stage equations are very low). Most of the literature on weak instruments deals with models of fixed coefficients. One standard recommendation is to estimate the model using LIML (e.g.,

Staiger and Stock (1997)). Therefore, we proceed by estimating the model by LIML. Here we present results for the main outcomes for the sample of white children. Panel B in Table 14 shows that, at ages 7-8, the LIML estimates are of the same sign than the original TSLS estimates in the paper, but they have larger absolute magnitudes and they are more imprecise (which would be a prediction of most of the literature).<sup>33</sup> This means that the TSLS estimates are closer to OLS than LIML, which is what we would expect if the instruments were weak. Notice also that, even with the imprecise LIML estimates, the effect of maternal schooling on white children cognitive development drops substantially from ages 7-8 to ages 10-12, while that is not the case for grade repetition and BPI. These results suggest that, although we may suffer from a weak instruments problem, if anything our estimates understate the true impact of maternal education on child outcomes since TSLS is biased towards OLS (and the latter are generally smaller than the former in absolute value). However, we need to be cautious about conclusions from these results, since the literature on weak instruments we draw on refers to a fixed coefficient model.

Another possible criticism of our procedure is that, since we are relying on interactions between controls and instruments, if the outcome equation is misspecified then some of our results might be driven by nonlinearities instead of genuine variation in the instruments. Therefore we re-estimate our model with a more flexible specification of the outcome equations, where we add the following variables to the set of controls: AFQT squared, grandmother's education squared, grandfather's education squared, and all two-way interactions between AFQT, grandmother's education, grandfather's education and whether the mother lived in a broken home at age 14. These additional controls are also interacted with the four group indicators. The IV estimates of the coefficient on maternal schooling are presented in the first row of Panel C of Table 14. The results are virtually unchanged by this additional set of controls.

Another specification check is reported in the second row of Panel C, in which we address the possible concern that the four subgroups of interest may follow group-specific trends, by including *group-specific* cohort indicators. Results are essentially

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<sup>33</sup>Panel A reproduces our base case result for easy reference.

Table 14: Sensitivity (white children)

Sensitivity analysis (white children)										
	PIAT math		PIAT read.		BPI		Grade repetition		Overweight	
	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs	7-8 yrs	12-14 yrs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
<b>Panel A: Base case</b>										
IV – Base case	0.0974 [0.0250]*** 2794	0.0648 [0.0280]** 2745	0.0582 [0.0277]** 2655	0.0515 [0.0312]* 2732	-0.0709 [0.0371]* 2889	-0.0711 [0.0341]** 2968	-0.0174 [0.00567]*** 1526	-0.0198 [0.00665]*** 2261	-0.0176 [0.0121] 2848	-0.000302 [0.0113] 2941
<b>Panel B: LIML</b>										
IV – LIML	0.137 [0.0536]** 2794	0.0734 [0.0516] 2745	0.0817 [0.0609] 2655	0.0454 [0.0619] 2732	-0.0681 [0.0839] 2889	-0.0794 [0.0871] 2968	-0.0264 [0.0175] 1526	-0.0251 [0.0132]* 2261	-0.0334 [0.0326] 2848	0.000851 [0.0211] 2941
<b>Panel C: Including additional controls</b>										
including polynomials and interactions	0.0995 [0.0247]*** 2794	0.0843 [0.0277]*** 2745	0.0609 [0.0274]** 2655	0.0697 [0.0297]** 2732	-0.0816 [0.0371]** 2889	-0.0823 [0.0347]** 2968	-0.0157 [0.00606]*** 1526	-0.0184 [0.00689]*** 2261	-0.0171 [0.0123] 2848	-0.00451 [0.0114] 2941
including group-specific cohort dummies	0.0896 [0.0252]*** 2794	0.0575 [0.0286]** 2745	0.0369 [0.0279] 2655	0.0423 [0.0296] 2732	-0.0850 [0.0377]** 2889	-0.0847 [0.0346]** 2968	-0.0159 [0.00556]*** 1526	-0.0166 [0.00658]** 2261	-0.0171 [0.0130] 2848	-0.00157 [0.0103] 2941
<b>Panel D: Varying the set of instruments</b>										
IV – Using both 2-year and 4-year tuition	0.0837 [0.0226]*** 2790	0.0477 [0.0260]* 2741	0.0446 [0.0244]* 2651	0.0355 [0.0279] 2728	-0.0890 [0.0321]*** 2885	-0.0588 [0.0309]* 2964	-0.0120 [0.00454]*** 1525	-0.0173 [0.00612]*** 2258	-0.0222 [0.0104]** 2844	-0.00365 [0.0104] 2937
IV – Excluding distance variable	0.112 [0.0282]*** 2794	0.0655 [0.0312]** 2745	0.0758 [0.0311]** 2655	0.0562 [0.0331]* 2732	-0.0586 [0.0387] 2889	-0.0658 [0.0371]* 2968	-0.0187 [0.00632]*** 1526	-0.0128 [0.00742]* 2261	-0.0122 [0.0130] 2848	-0.000331 [0.0125] 2941
IV – Excluding distance variable and tuition variable	0.124 [0.0337]*** 2794	0.0503 [0.0358] 2745	0.0673 [0.0373]* 2655	0.0748 [0.0394]* 2732	-0.0311 [0.0513] 2889	-0.0288 [0.0466] 2968	-0.0112 [0.00767] 1526	-0.0104 [0.00901] 2261	-0.0149 [0.0167] 2848	-0.0103 [0.0150] 2941
<b>Panel E: One observation per child, holding the sample of children constant across age groups</b>										
IV – One observation per child, holding the sample of children constant across age groups	0.0797 [0.0288]*** 1940	0.0585 [0.0309]* 1940	0.0560 [0.0308]* 1828	0.0491 [0.0323] 1828	-0.0852 [0.0391]** 2043	-0.0874 [0.0329]*** 2043	-0.0138 [0.00555]** 934	-0.0171 [0.00780]** 934	-0.0217 [0.0113]* 2024	0.00776 [0.0119] 2024

Note: This table reports IV estimates, showing the estimated average effect across all groups using the MD procedure as before. Panel A reproduces the main results for easy reference. Panel B shows LIML estimates. Panel C adds additional controls. ‘Polynomials and interactions’ includes polynomials of AFQT and grandparents’ education, and two-way interactions between AFQT, grandparents’ education, and broken home status. All of these additional regressors are also interacted with the four group indicators. ‘Group specific cohort dummies’ adds interactions of cohort indicators with group indicators to the base specification. Panel D presents IV estimates based on a modified set of the instruments. First, we use both 2-year and 4-year tuition. In the following, distance (and corresponding interactions) and distance and tuition (and corresponding interactions) are, respectively, excluded from the analysis. Panel E restricts the sample to those children who contribute observations to both age groups (age 7-8 and 12-14), and selects only the first observation from each age group. See text for details. \* indicates significance at 10%, \*\* indicates significance at 5%, \*\*\* indicates significance at 1% level.

unchanged except for PIAT reading. Panel D shows results where we vary the set of instruments we use. First, we include both 2-year and 4-year tuition measures as instruments. We then show results where we exclude the distance variable (and corresponding interactions), and then both distance and tuition (and corresponding interactions), so that the results rely only on opportunity cost variables. This kind of experiment is interesting as different instruments may affect different subgroups, and this approach has been used to compare returns for different groups (Cameron and Taber, 2004). There is of course a loss of efficiency connected to excluding some of the instruments, so the precision of these estimates is somewhat lower. The return in terms of PIAT scores for ages 7-8 goes up. When we exclude tuition as well, the BPI coefficient and the grade repetition coefficient go down and become insignificant. But overall, the results are very similar to the base case.<sup>34</sup>

Another concern is whether the age patterns between ages 7-8 and 12-14 may in part be driven by different samples between the two ages. In particular, some of the children included in the former age group may not have reached the latter in the window we observe. To investigate this, we present the following sensitivity check with a *balanced* panel of children. We restrict attention to all those children who contribute observations to both age brackets. We then select the earliest observation in each of those age groups, and re-estimate our results for our main outcomes. The results are shown in Panel E of Table 14, and they are very similar to our main results. This is reassuring as it indicates that sample selection is not driving the nature of our results.

## 5 Summary and Conclusion

In this paper we study the effect of maternal education on their children's outcomes, including cognitive development as measured by test score performance, behavioral problems, grade repetition, and health outcomes. We also examine home environments and parental investments. We instrument maternal schooling with local tuition fees, distance to college, and local labor market variables. In the outcome equations we

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<sup>34</sup>We should also mention that we have estimated more parsimonious models where we include state fixed effects instead of county fixed effects, which resulted in similar estimates to the ones we present.

condition on county and time effects, thus removing the impact of permanent differences and aggregate trends. We obtain additional variation in the instruments by allowing the effect to vary with family background of the mother.

Our results show that mother's education increases the child's performance in both math and reading at ages 7-8, but these effects tend to be smaller at ages 12-14. Maternal education also reduces the incidence of behavioral problems and reduces grade repetition, but we find no effect on obesity. More educated mothers delay childbearing, are more likely to be married, have substantially better educated spouses and higher family income. They are more likely to invest in their children through books, providing musical instruments, special lessons, or availability of a computer. Even though they work more, more educated mothers do not spend less time breastfeeding, reading to their children or taking them on outings. Finally, in adolescence (ages 18-19) we see that for blacks, maternal education reduces the number of children born to the young adults and the number of criminal convictions.

A policy implication is that intergenerational transmission is important for understanding long term policy effectiveness. This is important because many programmes are struggling to improve outcomes for poor children. Programmes which manage to increase mothers schooling are likely to be important not only for mothers now but also for their future children, and should be designed and judged with this in mind.

Our interest in understanding the effect of parental education on children's human capital is closely related to the study of intergenerational mobility. Solon (1999) points out that the high correlation between parental income and their offspring's income is well-documented, but that the underlying causes are not very well understood. Our findings suggest that parental educational choices may be an important transmission channel of intergenerational inequality, and support the view that educational policy can influence intergenerational mobility.

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# A Web Appendix

## A.1 Minimum Distance procedure

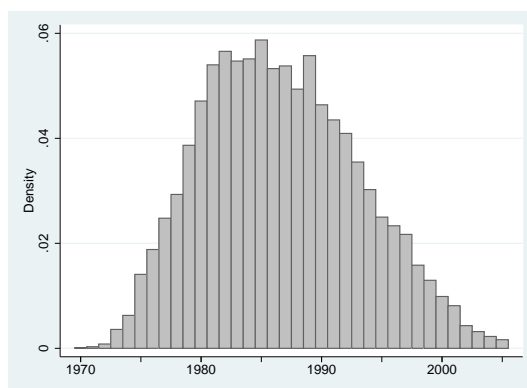
To estimate the average effect across groups, we apply the following Minimum Distance procedure (Chamberlain, 1984). Specifically, we are interested in the restricted coefficient  $\theta$  in the equation

$$K\theta - \beta = 0$$

where  $\beta = [\beta_1 \beta_2 \beta_3 \beta_4]'$  is the 4-by-1 coefficient vector from equation (1),  $\theta$  is the (unknown) constrained coefficient (vector) of interest, and  $K$  is a matrix containing the restrictions. For example, to compute the overall effect of mother's education, we set  $K = [1 \ 1 \ 1 \ 1]'$ . Then the constrained estimator is  $\theta = (K'V^{-1}K)^{-1}K'V^{-1}\beta$ , where  $V$  is the variance-covariance matrix of  $\beta$ . The outcome tables (e.g. Table 4) report the resulting estimates for  $\theta$  (replacing  $\beta$  and  $V$  with the corresponding estimates from equation (1)). The corresponding variance-covariance matrix of  $\theta$  is  $\Sigma(\theta) = (K'V^{-1}K)^{-1}$ . To compute minimum distance estimates for other groups of interest, e.g. average effects for high and low AFQT mothers, we follow the same procedure with a different matrix  $K$ .

## A.2 Additional figures and tables

Figure 1: Distribution of child birth cohorts



Source: NLSY79 and Children of the NLSY79.

Table 15: Family environment – OLS results: White children

<b>OLS estimates: White children (7-8 years)</b>							
	Maternal age	Number of children	Marital status	Spouse schooling	Hours worked	Lg family income	Maternal aspirations
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Impact of Maternal Schooling for:							
Whole sample	1.104 [0.0566]***	-0.0343 [0.0221]	0.0192 [0.00559]***	0.541 [0.0382]***	69.54 [12.40]***	0.127 [0.0113]***	0.0498 [0.00774]***
Males	1.115 [0.0677]***	-0.0349 [0.0237]	0.0211 [0.00669]***	0.556 [0.0429]***	76.70 [15.03]***	0.133 [0.0141]***	0.0477 [0.00927]***
Females	1.090 [0.0745]***	-0.0334 [0.0252]	0.0172 [0.00666]***	0.523 [0.0454]***	62.27 [15.11]***	0.122 [0.0130]***	0.0524 [0.0100]***
High maternal AFQT	1.088 [0.0751]***	-0.0299 [0.0277]	0.0184 [0.00650]***	0.545 [0.0535]***	54.06 [16.66]***	0.127 [0.0149]***	0.0452 [0.00903]***
Low maternal AFQT	1.124 [0.0843]***	-0.0424 [0.0377]	0.0212 [0.0103]**	0.537 [0.0568]***	89.82 [19.14]***	0.126 [0.0161]***	0.0595 [0.0126]***
Impact of Maternal AFQT	-0.259 [0.205]	0.0770 [0.0902]	0.0313 [0.0219]	0.0273 [0.148]	145.6 [49.26]***	0.207 [0.0471]***	0.00490 [0.0321]
Observations	4743	4743	4738	3623	4648	4109	1417
Mean	25.03	2.766	0.776	13.37	1161.6	3.740	0.773
Standard deviation	5.229	1.221	0.417	2.551	953.8	0.930	0.419

Note: Table reports Minimum Distance estimates based on equation (1), see text for details. Standard errors in brackets, clustered by county-cohort. \* indicates significance at 10%, \*\* at 5%, \*\*\* at 1%.

Table 16: Family environment – OLS results: Black children

<b>OLS estimates: Black children (7-8 years)</b>							
	Maternal age	Number of children	Marital status	Spouse schooling	Hours worked	Lg family income	Maternal aspirations
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Impact of Maternal Schooling for:							
Whole sample	1.151 [0.0847]***	-0.189 [0.0311]***	0.0369 [0.0105]***	0.467 [0.0686]***	174.9 [16.38]***	0.126 [0.0151]***	0.0718 [0.0147]***
Males	1.242 [0.105]***	-0.210 [0.0367]***	0.0509 [0.0126]***	0.456 [0.0752]***	178.7 [19.01]***	0.142 [0.0169]***	0.0730 [0.0169]***
Females	1.038 [0.114]***	-0.175 [0.0334]***	0.0256 [0.0119]**	0.479 [0.0751]***	169.7 [21.18]***	0.0995 [0.0195]***	0.0696 [0.0207]***
High maternal AFQT	1.348 [0.136]***	-0.170 [0.0461]***	0.0286 [0.0180]	0.390 [0.102]***	97.46 [27.02]***	0.129 [0.0288]***	0.0337 [0.0231]
Low maternal AFQT	1.024 [0.109]***	-0.203 [0.0406]***	0.0410 [0.0127]***	0.531 [0.0927]***	216.5 [20.04]***	0.125 [0.0173]***	0.0926 [0.0177]***
Impact of Maternal AFQT	-0.173 [0.290]	0.0123 [0.106]	0.0843 [0.0393]**	-0.0315 [0.223]	147.8 [73.92]**	0.222 [0.0711]***	0.0756 [0.0560]
Observations	2735	2735	2733	991	2710	2203	468
Mean	22.47	3.105	0.382	12.73	1150.4	3.033	0.660
Standard deviation	4.953	1.419	0.486	2.098	995.5	0.886	0.474

Note: Table reports Minimum Distance estimates based on equation (1), see text for details. Standard errors in brackets, clustered by county-cohort. \* indicates significance at 10%, \*\* at 5%, \*\*\* at 1%.

Table 17: Investments – OLS results: White children

OLS estimates: White children								
	Museum 7-8 yrs	Musical Instr. 7-8 yrs	Special lesson 7-8 yrs	Mother reads 7-8 yrs	Newspaper 7-8 yrs	Computer 12-14 yrs	Adult home 12-14 yrs	Joint meals 12-14 yrs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Impact of Maternal Schooling for:								
Whole sample	0.0334 [0.00689]***	0.0433 [0.00660]***	0.0455 [0.00595]***	0.0352 [0.00639]***	0.0113 [0.00776]	0.0561 [0.00857]***	0.00318 [0.00687]	0.00457 [0.00803]
Males	0.0366 [0.00868]***	0.0440 [0.00801]***	0.0441 [0.00740]***	0.0364 [0.00780]***	0.0114 [0.00935]	0.0585 [0.0116]***	0.00804 [0.00885]	0.00948 [0.00981]
Females	0.0299 [0.00895]***	0.0426 [0.00830]***	0.0472 [0.00795]***	0.0336 [0.00887]***	0.0112 [0.00933]	0.0542 [0.0107]***	-0.00256 [0.00952]	-0.000544 [0.00994]
High maternal AFQT	0.0315 [0.00854]***	0.0363 [0.00895]***	0.0445 [0.00735]***	0.0333 [0.00844]***	0.0143 [0.00988]	0.0396 [0.0115]***	0.000191 [0.00979]	-0.00217 [0.0101]
Low maternal AFQT	0.0367 [0.0113]***	0.0524 [0.0102]***	0.0475 [0.0110]***	0.0379 [0.0100]***	0.00719 [0.0114]	0.0770 [0.0130]***	0.00618 [0.00980]	0.0154 [0.0127]
Impact of Maternal AFQT	-0.00281 [0.0269]	0.0382 [0.0285]	0.0223 [0.0257]	-0.0183 [0.0269]	0.0489 [0.0281]*	0.0252 [0.0323]	-0.0531 [0.0269]**	-0.0107 [0.0308]
Observations	2976	2975	2974	2981	2977	1681	2682	2975
Mean	0.419	0.539	0.685	0.495	0.531	0.681	0.681	0.560
Standard deviation	0.494	0.499	0.465	0.500	0.508	0.466	0.466	0.496

Note: Table reports Minimum Distance estimates based on equation (1), see text for details. Standard errors in brackets, clustered by county-cohort. \* indicates significance at 10%, \*\* at 5%, \*\*\* at 1%.

Table 18: Investments – OLS results: Black children

OLS estimates: Black children								
	Museum 7-8 yrs (1)	Musical Instr. 7-8 yrs (2)	Special lesson 7-8 yrs (3)	Mother reads 7-8 yrs (4)	Newspaper 7-8 yrs (5)	Computer 12-14 yrs (6)	Adult home 12-14 yrs (7)	Joint meals 12-14 yrs (8)
Impact of Maternal Schooling for:								
Whole sample	0.0313 [0.00947]***	0.0405 [0.0105]***	0.0692 [0.0102]***	0.0601 [0.0104]***	-0.00527 [0.0116]	0.0492 [0.0141]***	-0.0137 [0.00953]	0.00974 [0.0108]
Males	0.0315 [0.0124]**	0.0333 [0.0119]***	0.0608 [0.0140]***	0.0558 [0.0138]***	0.00000267 [0.0134]	0.0557 [0.0172]***	-0.0157 [0.0134]	0.00937 [0.0136]
Females	0.0310 [0.0130]**	0.0537 [0.0149]***	0.0757 [0.0126]***	0.0637 [0.0129]***	-0.0145 [0.0164]	0.0411 [0.0187]**	-0.0121 [0.0119]	0.0101 [0.0128]
High maternal AFQT	0.0338 [0.0186]*	0.0409 [0.0187]**	0.0928 [0.0173]***	0.0574 [0.0164]***	-0.00943 [0.0184]	0.0562 [0.0244]**	0.00459 [0.0152]	0.0186 [0.0160]
Low maternal AFQT	0.0303 [0.0113]***	0.0403 [0.0122]***	0.0572 [0.0124]***	0.0616 [0.0124]***	-0.00242 [0.0151]	0.0459 [0.0170]***	-0.0224 [0.0111]**	0.00325 [0.0138]
Impact of Maternal AFQT	-0.00928 [0.0396]	0.0124 [0.0417]	0.0227 [0.0409]	-0.0643 [0.0400]	0.103 [0.0461]**	0.0902 [0.0483]*	-0.0116 [0.0412]	-0.0627 [0.0427]
Observations	1389	1388	1388	1391	1390	906	1549	1650
Mean	0.405	0.352	0.453	0.331	0.413	0.352	0.701	0.316
Standard deviation	0.491	0.478	0.498	0.471	0.493	0.478	0.458	0.465

Note: Table reports Minimum Distance estimates based on equation (1), see text for details. Standard errors in brackets, clustered by county-cohort. \* indicates significance at 10%, \*\* at 5%, \*\*\* at 1%.

Table 19: Early outcomes – OLS results

OLS estimates: Children 0-1 years				
	Whites		Blacks	
	Low birthweight	MSD	Low birthweight	MSD
	(1)	(2)	(3)	(4)
Impact of Maternal Schooling for:				
Whole sample	-0.00107	-0.0423	-0.00501	0.0165
	[0.00293]	[0.0155]***	[0.00654]	[0.0362]
Males	-0.00425	-0.0394	-0.00575	0.0204
	[0.00368]	[0.0180]**	[0.00755]	[0.0389]
Females	0.00397	-0.0476	-0.00388	0.00420
	[0.00459]	[0.0225]**	[0.00870]	[0.0572]
High maternal AFQT	-0.00320	-0.0446	0.00368	-0.0188
	[0.00351]	[0.0179]**	[0.00884]	[0.0574]
Low maternal AFQT	0.00326	-0.0364	-0.0139	0.0364
	[0.00491]	[0.0285]	[0.00892]	[0.0441]
Impact of Maternal AFQT	-0.00609	-0.0402	-0.00328	-0.203
	[0.0116]	[0.0624]	[0.0235]	[0.131]
Observations	5590	2145	2811	787
Mean	0.0649	-0.0390	0.130	0.181
Standard deviation	0.246	0.994	0.337	1.215

Note: Table reports Minimum Distance estimates based on equation (1), see text for details. Standard errors in brackets, clustered by county-cohort. \* indicates significance at 10%, \*\* at 5%, \*\*\* at 1%.

Table 20: Early channels – OLS results: white children

OLS estimates: White children 0-1 years								
	Smoking d. pregnancy	Weeks breastfeeding	Formal child care	Hours worked	Mother reads	Book	Soft toys	Outings
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Impact of Maternal Schooling for:								
Whole sample	-0.0679	1.347	0.0102	112.0	0.0329	0.0857	-0.177	0.0170
	[0.00643]***	[0.345]***	[0.00300]***	[10.36]***	[0.00604]***	[0.0131]***	[0.171]	[0.00579]***
Males	-0.0695	0.973	0.00820	119.1	0.0381	0.100	-0.154	0.0162
	[0.00760]***	[0.409]**	[0.00361]**	[11.75]***	[0.00825]***	[0.0172]***	[0.201]	[0.00721]**
Females	-0.0660	1.882	0.0132	101.3	0.0280	0.0728	-0.222	0.0180
	[0.00803]***	[0.468]***	[0.00421]***	[13.35]***	[0.00810]***	[0.0165]***	[0.263]	[0.00782]**
High maternal AFQT	-0.0625	1.365	0.0126	94.33	0.0302	0.0797	-0.192	0.00804
	[0.00802]***	[0.419]***	[0.00443]***	[13.72]***	[0.00718]***	[0.0155]***	[0.223]	[0.00730]
Low maternal AFQT	-0.0769	1.300	0.00819	134.1	0.0402	0.101	-0.153	0.0322
	[0.0103]***	[0.708]*	[0.00413]**	[15.27]***	[0.0120]***	[0.0242]***	[0.300]	[0.00947]***
Impact of Maternal AFQT	-0.0819	1.031	0.0230	74.99	0.0191	0.106	2.303	0.0126
	[0.0274]***	[1.352]	[0.00885]***	[38.85]*	[0.0277]	[0.0522]**	[0.657]***	[0.0242]
Observations	5649	3234	4888	5990	2403	2427	2387	2425
Mean	0.351	22.23	0.0671	928.0	0.610	3.251	16.66	0.752
Standard deviation	0.477	21.98	0.250	881.0	0.488	1.059	12.42	0.432

Note: Table reports Minimum Distance estimates based on equation (1), see text for details. Standard errors in brackets, clustered by county-cohort. \* indicates significance at 10%, \*\* at 5%, \*\*\* at 1%.

Table 21: Early channels – OLS results: Black children

OLS estimates: Black children 0-1 years								
	Smoking d. pregnancy	Weeks breastfeeding	Formal child care	Hours worked	Mother reads	Book	Soft toys	Outings
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Impact of Maternal Schooling for:								
Whole sample	-0.0450 [0.00934]***	0.747 [0.728]	0.0207 [0.00464]***	176.4 [14.40]***	0.0580 [0.0130]***	0.185 [0.0301]***	0.323 [0.232]	0.0138 [0.0109]
Males	-0.0380 [0.0114]***	0.383 [0.947]	0.0171 [0.00558]***	173.3 [17.04]***	0.0659 [0.0150]***	0.187 [0.0371]***	0.517 [0.298]*	0.0205 [0.0153]
Females	-0.0509 [0.0108]***	1.108 [0.944]	0.0249 [0.00588]***	179.3 [16.81]***	0.0437 [0.0187]**	0.183 [0.0379]***	0.179 [0.270]	0.00721 [0.0152]
High maternal AFQT	-0.0419 [0.0116]***	-1.117 [1.139]	0.0250 [0.00846]***	137.5 [27.52]***	0.0680 [0.0225]***	0.202 [0.0430]***	0.499 [0.429]	-0.00576 [0.0170]
Low maternal AFQT	-0.0497 [0.0139]***	1.650 [0.843]*	0.0190 [0.00543]***	191.3 [16.99]***	0.0522 [0.0168]***	0.174 [0.0363]***	0.240 [0.286]	0.0288 [0.0147]*
Impact of Maternal AFQT	0.00766 [0.0344]	1.798 [2.749]	0.00692 [0.0148]	151.3 [59.66]**	0.00529 [0.0460]	0.138 [0.0953]	-1.496 [0.923]	0.0359 [0.0367]
Observations	2803	632	2260	2977	906	909	901	909
Mean	0.295	18.09	0.0695	770.1	0.374	2.353	11.18	0.703
Standard deviation	0.456	19.26	0.254	886.6	0.484	1.193	10.04	0.457

Note: Table reports Minimum Distance estimates based on equation (1), see text for details. Standard errors in brackets, clustered by county-cohort. \* indicates significance at 10%, \*\* at 5%, \*\*\* at 1%.

Table 22: Young adults – OLS results

OLS estimates: Young adults (18-19 years)						
	White			Black		
	Enrollment	Conviction	Own children	Enrollment	Conviction	Own children
	(1)	(2)	(3)	(4)	(5)	(6)
Impact of Maternal Schooling for:						
Whole sample	0.0203 [0.00890]**	-0.0106 [0.00569]*	-0.0116 [0.00433]***	0.0300 [0.0115]***	-0.0144 [0.00689]**	-0.0224 [0.00873]**
Males	0.0182 [0.0106]*	-0.0239 [0.00894]***	-0.00439 [0.00519]	0.0342 [0.0160]**	-0.0451 [0.0124]***	-0.0171 [0.00915]*
Females	0.0233 [0.0119]*	-0.000869 [0.00757]	-0.0279 [0.00778]***	0.0264 [0.0151]*	-0.00614 [0.00743]	-0.0483 [0.0161]***
High maternal AFQT	0.0190 [0.0114]*	-0.000209 [0.00795]	-0.0105 [0.00659]	0.0118 [0.0165]	-0.0341 [0.0124]***	-0.0268 [0.0133]**
Low maternal AFQT	0.0219 [0.0120]*	-0.0221 [0.00843]***	-0.0124 [0.00571]**	0.0439 [0.0146]***	-0.00711 [0.00788]	-0.0191 [0.0114]*
Impact of Maternal AFQT	0.0117 [0.0294]	-0.0313 [0.0205]	0.00677 [0.0141]	-0.0504 [0.0417]	-0.0291 [0.0244]	-0.00354 [0.0325]
Observations	1597	1672	1494	1027	1155	988
Mean	0.700	0.149	0.0703	0.691	0.130	0.148
Standard deviation	0.458	0.356	0.266	0.462	0.336	0.396

Note: Table reports Minimum Distance estimates based on equation (1), see text for details. Standard errors in brackets, clustered by county-cohort. \* indicates significance at 10%, \*\* at 5%, \*\*\* at 1%.



Table 23: Correlation matrix

	PIAT math (age 7-8)		BPI (age 7-8)	
	Whites	Blacks	Whites	Blacks
<i>Early investments (ages 0-1)</i>				
Smoking during pregnancy	-0.1333	-0.0353	0.1626	0.1035
Weeks breastfeeding	0.1348	0.0347	-0.0766	-0.0961
Formal child care	0.0790	0.0928	-0.0248	-0.0726
Hours worked	0.1255	0.1616	-0.0628	-0.1325
Mother reads	0.0804	0.1154	-0.0935	-0.1157
Books	0.1236	0.1938	-0.1236	-0.2047
Soft toys	-0.0063	0.0866	-0.0344	-0.0809
Outings	0.0274	0.0564	-0.0822	-0.1215
<i>Family environment (ages 7-8)</i>				
Maternal age	0.2131	0.1139	-0.2067	-0.1893
Number of children	-0.0919	-0.1895	-0.0397	0.1248
Marital status	0.1429	0.1064	-0.1697	-0.1457
Spouse's schooling	0.2773	0.2058	-0.1468	-0.0596
Hours worked	0.0307	0.1558	0.0167	-0.1384
Log family income	0.2166	0.2140	-0.1973	-0.1843
Maternal aspirations	0.2733	0.3025	-0.2360	-0.1906
<i>Parental investment measures (ages 7-8)</i>				
Museum	0.1097	0.1226	-0.0785	-0.1076
Musical instrument	0.1634	0.1326	-0.0998	-0.1560
Special lessons	0.2104	0.1321	-0.1846	-0.0838
Mother reads	0.0105	0.0303	-0.1126	-0.0966
Newspaper	0.0892	0.0077	-0.1188	-0.0418

Note: Table displays simple pairwise correlation coefficient between variables indicated in the column and row, respectively. For each child, we compute the average of all available observations of the relevant variable in the relevant age range. Includes one observation per child.

Table 24: Sensitivity analysis regarding sample for early adolescence outcomes – sample characteristics

	Whites		Blacks	
	Full sample	restricted	Full sample	restricted
	(1)	(2)	(3)	(4)
Mother's yrs. of schooling	13.412 [2.292]	12.649 [1.869]	12.740 [1.966]	12.389 [1.795]
Mother's AFQT (corrected)	0.406 [0.879]	0.241 [0.873]	-0.440 [0.786]	-0.496 [0.747]
Grandmother's yrs. of schooling	11.813 [2.288]	11.388 [2.287]	10.603 [2.684]	10.445 [2.746]
Grandfather's yrs. of schooling	11.924 [3.136]	11.374 [3.031]	9.878 [3.642]	9.627 [3.616]
'Broken home' status	0.203 [0.402]	0.228 [0.420]	0.438 [0.496]	0.440 [0.497]
Maternal age at birth	26.618 [5.100]	23.161 [3.332]	24.205 [5.145]	21.691 [3.272]
Child age (months)	95.262 [6.974]	95.681 [6.847]	95.900 [6.957]	95.873 [6.791]
Child female	0.498 [0.500]	0.499 [0.500]	0.501 [0.500]	0.502 [0.500]
Observations	2794	1519	1346	932

Note: Table shows sample means for children included in the PIAT math regression for ages 7-8. Columns (1) and (3) show means for full sample (as in Table 2), while (2) and (4) restrict to those children who contribute at least one observation to the early adolescence outcomes. See text for details.

Table 25: Sensitivity analysis regarding sample for early adolescence outcomes – IV results

	White children				Black children			
	PIAT math 7-8 yrs	PIAT read. 7-8 yrs	BPI 7-8 yrs	Overweight 7-8 yrs	PIAT math 7-8 yrs	PIAT read. 7-8 yrs	BPI 7-8 yrs	Overweight 7-8 yrs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<b>Panel A: full sample</b>								
IV - full sample	0.0974 [0.0250]*** 2794	0.0582 [0.0277]** 2655	-0.0709 [0.0371]* 2889	-0.0176 [0.0121] 2848	0.0958 [0.0326]*** 1346	0.116 [0.0286]*** 1255	-0.0678 [0.0418] 1314	0.0113 [0.0141] 1323
<b>Panel B: sample restricted</b>								
IV - restricted sample	0.0614 [0.0312]** 1519	0.0264 [0.0335] 1421	-0.125 [0.0479]*** 1528	-0.0185 [0.0135] 1487	0.0622 [0.0322]* 932	0.102 [0.0321]*** 861	-0.130 [0.0453]*** 898	-0.00126 [0.0143] 900

Note: This table reports IV estimates, showing the estimated average effect across all groups using the MD procedure as before. Panel A reproduces the main results for easy reference. Panel B restricts the sample to all those children who contribute at least one observation to the early adolescence outcomes. See text for details. \* indicates significance at 10%, \*\* indicates significance at 5%, \*\*\* indicates significance at 1% level.