Birth Order and Child Outcomes: Does Maternal Quality Time Matter?

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Abstract

Higher birth order positions are associated with poorer outcomes, possibly due to less resources received within the household. Using a sample of PSID-CDS sibling pairs, this research investigates whether the birth order effects in children outcomes are due to differences in maternal quality time inputs. While the OLS results show negative birth order and positive maternal time effects on various test scores, household fixed effects estimation suggests that birth order effects do not stand for differences in maternal quality time received.

Keywords: birth order; child outcome; time use **JEL:** D13, J12, J13, J22, J24

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1 Introduction

Inequalities among individual outcomes have recently been examined in line with the evolution of household conditions, as family sizes become smaller, and as more women enter the labor force and decide to bear children at later years. A growing literature rests on how family size and birth order are associated with inequalities in achievements and outcomes. Though pioneer studies fall under the fields of psychology and sociology, researches for economics are rapidly catching up, investigating education and income outcomes, among others. Results predominantly show that individuals from larger family sizes have lower adult educational attainment and earnings (Gary-Bobo, Prieto, and Picard 2006; Black, Devereux, and Salvanes 2005), since family resources have to be divided among a greater number of offsprings. And because those of higher birth order positions are born into larger family sizes, they are likewise found to have worse outcomes than those of lower birth order positions (Kantarevic and Mechoulan 2005).

Even with a growing literature examining the link between birth order and individual outcomes, the studies that look at children-level outcomes still remain rather limited in number, mainly due to the absence of appropriate data and exposure (Behrman and Taubman 1986). Moreover, establishing a causal relationship between birth order and children outcomes remains a challenge, particularly in disentangling the various confounding factors associated with both. Nevertheless, a possible link between birth order and children outcomes may lie on parental investments on their children. Successfully establishing the existence of this link may not only provide a possible answer to overcome birth order effects, if present, but also lend a better explanation to the mechanism of intergenerational transmission.

Financial, material, and time resources may be considered as investments into the child "quality" production (Becker 1974). Parental investments on their children, in turn, not only differ according to family finances and parental characteristics such as educational attainment, but also according to child-specific characteristics such as gender,

birth order position, and number of children born in the family. For instance, a larger family size leads to fewer share of resources per child, given that family resources have to be divided among a greater number of children, assuming parents aspire to provide equally among their children. Birth order effects could favor the children with lower birth order positions essentially because they were born earlier and have received more resources from the parents.

Among the resource allocated by parents to children, time investments particularly that of the mother, is believed to be a crucial factor that contributes to the improvement of child educational and human capital outcomes. In line with the differences in intra-household allocation of resources, Price (2008) showed that while parents provide roughly equal time to each child at a given point in time, "birth order effects" come about due to the decreasing time that parents spend with their children as both get older. The result is that first-born children receive more cumulative quality time from the parents as compared to their second-born counterparts. This brings forth the argument that birth order effects in children outcomes may be due to the differences in time resources received from parents.

This paper provides the first empirical assessment of the above argument by exploring the following research question: Does "birth order effect" mask differences in parental quality time received by the child? It is possible to answer this question by using Child Development Supplement (CDS) of the Panel Study of Income Dynamics (PSID), a longitudinal survey on socio-economic conditions of interviewed families and individuals. This supplement includes a time diary that contains information on how children spend their time on a representative weekday and weekend, how long they do certain activities, and with whom, including their parents. When the interest is focused on parental time with children, time diaries provide a significant advantage over using proxies such as employment status or weekly work hours. This research focuses on maternal time, following the emphasis provided by existing literature, although estimated results show similar findings for paternal time. To empirically test for whether resource allocation explains the

link between birth order and child outcomes, as suggested by Price (2008), this research bridges two streams of literature - that of child production and that of intrahousehold allocation of resources.

The results in this paper show a negative relationship between child cognitive test scores and birth order. Similarly, a negative relationship is found between maternal quality time and birth order, in line with Price (2008). However, the explanation for this pattern does not seem to rest on equity heuristic, evidenced by unequal time allocation at each point in time. To test whether the first effect is also capturing different allocation of time resources, birth order and maternal time are both inserted as regressors. Ordinary least squares regression results show significant negative birth order effects and positive maternal time effects, with the magnitude of the birth order coefficients slightly diminished with the inclusion of maternal time. Once unobserved household-specific heterogeneity are controlled for using sibling difference, maternal quality time loses its significance, while the coefficients of the birth order variables remain negative and statistically significant. This suggests that "birth order effects" do not mask differences in maternal quality time received.

The paper is organized as follows. Section 2 presents existing evidence for birth order effects. Section 3 discusses the methodology, as well as the data source and variables used. Section 4 shows the descriptive and empirical results. Lastly, Section 5 concludes.

2 Background

2.1 *Birth Order and Outcomes*

Existing literature of the so-called "birth order effects" have largely been prevalent in the field of psychology (Kidwell 1981; Sulloway 2007; Zajonc 1976), exploring outcomes such as intellectual attainments and personalities due to differing intellectual environments experienced by the children, as proposed by the confluence model (Zajonc 1976), or by distinct roles that each child plays in the family, as suggested by the family dynamics

model (Sulloway 2007). Adoption into the field of economics remains relatively new, focusing mainly on inequalities in human capital and labor market outcomes measured in terms of educational attainment (Blake 1981; Black, Devereux, and Salvanes 2005; Booth and Kee 2005; Kantarevic and Mechoulan 2006), test scores (Blake 1981; Conley, Pfeiffer, and Velez 2007), and income earnings (Behrman and Taubman 1986; Kantarevic and Mechoulan 2006).

Although there are some studies that claim little or no birth order effect (e.g. Hauser and Sewell 1985), most empirical findings in the economic literature show negative or U-shaped results (Hanushek 1992). Among those that looked at birth order effects in educational outcomes, Heiland (2009) found that U.S. first-borns of the 1979 cohort of National Longitudinal Survey of Youth (NLSY79) have higher scores in the Peabody Picture Vocabulary Test-Revised (PPVT-R), a standardized test of early verbal ability. He also addressed the issue of omitted variables by applying random effects, family fixed effects, and sibling first difference. Another longitudinal survey available for such analysis is the Panel Study of Income Dynamics (PSID) and its Child Development Supplement (CDS). Using the main dataset, Kantarevic and Mechoulan (2005) applied a family fixed effects estimation and claimed that a "first-born advantage" in terms of educational attainment is already evident as early as high school age, which persists until the professional life as measured by income earnings. With the children sample, Conley, Pfeiffer, and Velez (2007) applied a sibling difference approach and found that first-borns generally perform better in Woodcock-Johnson Revised (WJ-R) Tests of Achievement than how their younger siblings fare. Meanwhile, Black, Devereux, and Salvanes (2007) used a family fixed effects estimation on a Norwegian sample and found that lower birth order children have higher scores in intellectual quotient.

The negative relationship between birth order and outcomes is hypothesized to be due to how resources are allocated within the household. Assuming that provision of greater resources improves children outcomes, a family with a greater number of children lets each child receive a smaller share of the family resources, as compared to a child born in

a smaller family (Becker 1974; Becker and Tomes 1976). As higher birth order children are more likely to be born in bigger families, a latter-born child will also receive fewer resources, since the resources have already been previously allocated to the earlier-born children. Becker and Lewis (1973) proposed a quantity-quality trade-off in the family, saying that larger family sizes produce lower "quality" children since more people have to share the available resources. Similarly, higher birth order children who come from larger families receive less resources and have poorer outcomes. Siblings with a smaller age gap also have a greater propensity towards sibling competition for parental resources than do siblings with a larger age gap, hence the former are more likely to receive less resources and experience birth order effects. Empirical findings on the resource dilution hypothesis, or such phenomena of depletion of the limited parental resources confirm this negative relationship between birth order and resources (Blake 1981; Leibowitz 1974; Booth and Kee 2009).

Even if parents decide to allocate resources more equally among the children, the result still creates a cumulative inequality. This is the so-called equity heuristic model proposed by Hertwig, Davis, and Sulloway (2002). Compared to the first-borns who enjoy being the "only child" when the younger siblings have not been born, and the last-born children who become the "only child" when the older siblings leave the household, middle-born children never have the opportunity of being the "only child" in the family. As such, middle-born children always share the parental resources with other siblings and always receive lesser cumulative shares of the resources. Unlike the earlier-born children, latter-born children experience a poorer resource environment, such as less parental time during the child's early years. One reason for birth order effects within the equity heuristic framework is that they may be more of a function of perception than actual, such that children perceive themselves as being treated unequally, even though they are treated equally. Parents may also have a different definition of "equality" from the children's. Nevertheless, the equity heuristic shows that birth order effects may occur even though parents aim to be equal at all times. If the birth order effects in individual outcomes are

indeed caused by the differences in resources received, first-born children are expected to have received more resources than their latter-born siblings did. With a neighbor-matching estimation that allows for the comparison of first-borns and second-borns from similar two-children households of American Time Use Survey (ATUS) respondents, Price (2008) found that parents provide approximately equal amounts of quality time to their children at each point in time, but spend less time with each child as they both get older, resulting in less cumulative parental quality time by second-born children.

2.2 *Intrahousehold Resource Allocation and Child Outcomes*

Researches on the child production function initially developed by Becker and Tomes (1976) have proposed that child outcomes result from a combination of inputs such as material/financial and time. More inputs invested will produce children of better outcomes. Material and financial inputs have been proxied by family income and parental education, while attempts on considering the temporal resources have started out with the usage of proxies such as parental employment and weekly work hours (Bernal 2008; Todd and Wolpin 2003; Blau and Grossberg 1992). A novelty that has recently developed regarding the analysis of time allocation is the use of time diaries, which provide significantly better estimates. The proxies provide the minimum amount of time not spent with children, since non-working time of parents are not necessarily and entirely used together with their children. Time diaries, on the other hand, provide the amount of time that parents are actually with their children, in addition to providing information on the activities performed together. A limited literature has looked at time inputs as a determinant of child outcomes, mostly using the PSID-CDS. Hsin (2007) applied ordinary least sqaures estimations to look at the relationship between childcare/parental time and children outcomes, examining how different measures of maternal care (i.e. total quantity, engaged, quality time) observed in 1997 affect children outcomes measured in 2002. She found that more time spent with mothers has a positive effect on the verbal skills of the children, but only for the children whose mothers have high verbal abilities.

Applying a generalized propensity score, Carneiro and Rodrigues (2009) concluded that more time spent with mothers leads to better cognitive test outcomes, at least for the younger children. Meanwhile, Del Boca, Flinn, and Wiswall (2010) estimated a model of the cognitive developmental process of the children nested within the life cycle behavior of the household, and showed parental active time as a productive input for young children, though with declining effect.

The purpose of this research is to understand whether birth order effects in children outcomes mask the differences in resources received in the household, specifically, whether differences in various test outcomes are due to differences in maternal quality time received.

3 Data and empirical strategy

Data used in this paper comes from the three waves of the Child Development Supplement (CDS) of the Panel Study of Income Dynamics (PSID). The Panel Study of Income Dynamics is primarily sponsored by the National Science Foundation, the National Institute of Aging, and the National Institute of Child Health and Human Development and is conducted by the University of Michigan. The study is a longitudinal data of United States individuals, with information regarding their economic, demographic, sociological, and psychological status and well-being. The interview started in 1968, with the initial sample of 4,800 families coming from a cross-sectional national sample drawn by the Survey Research Center (SRC) and a national sample of low-income families from the Survey of Economic Opportunity (SEO) conducted by the Bureau of the Census for the Office of Economic Opportunity. The succeeding interviews followed the original sample through the years. As of 2001, there are more than 7,000 interview families in the dataset. The latest available wave of the PSID is of year 2007.

The CDS dataset was funded by the National Institute of Child Health and National Development (NICHD), with the first interview in 1997. The second wave is in 2002/03,

and the third is in 2007. The CDS-I contains 3,563 children of 0 to 12 years old belonging to 2,394 families (88%). The CDS-II successfully re-interviewed 2,907 children from 2,019 families (91%), with ages 5 to 18, while the CDS-III has 1,506 children (90%) re-interviews, of 10 to 19 years old. Children from the original sample of 18 years or above are included in the Transition into Adulthood (TA) dataset.

The CDS looks into the human capital development of the interviewed children, with measures such as home environment, family processes, time diaries, school environment, and measures of cognitive, emotional, and physical performance. Information for up to two randomly-chosen children in a family are available. The time diaries contain the activities performed by each child on a weekday and a weekend, how long the activities were performed, and with whom. Cognitive measurements include verbal outcomes of letter word (LW) that captures symbolic learning and reading identification skills, and passage comprehension (PC) that captures comprehension and vocabulary skills. Practical mathematical problems are measured by applied problem (AP). These are available in both raw and standardized formats. The former essentially counts the number of items correctly answered, while the latter is constructed based on the child's raw score and age. A subjective non-cognitive measure of behavioral problem index (BPI) is also available, which includes information on mood swings, aggression, etc.

In order to test for the role of parental time in shaping the relationship between birth order and child outcomes (Price 2008) an unique feature of CDS is exploited, i.e. the availability of information on both parental time use and children outcomes. This makes it possible to identify birth order effects in a child outcome equation with or without conditioning for parental time. Moreover, thanks to the presence of a sample of sibling pairs in the data, the above mentioned evaluation can be performed net of unobservable household characteristics.

3.1 *Birth Order and Maternal Quality Time*

To investigate that "birth order effects" for the different children outcomes are coursed through parental quality time, the relationship between birth order and quality time must first be established. If birth order effects hold true for parental time, this provides evidence about the importance of inserting both variables in the child outcome equation.

Figure 1 exhibits the general declining pattern for average maternal quality time received by birth order positions. Children of higher birth order positions receive less maternal quality time than do children of lower birth order positions. Average quality time later in life (2002) are also much less compared to that received earlier in life (1997). This is consistent with Price (2008). However, the idea that parents allocate equal amounts of quality time to their children at a given point in time appears contraddicted, given the decreasing patterns visible in both waves. If parents indeed allocated equal amounts of time among their children at a given period, the graph should exhibit a horizontal or constant pattern across the different birth order positions.

[Figure 1 near here]

To ensure that this birth order pattern is not confounded with others factors such as age and gender, maternal quality time is regressed on the different birth order positions, controlling for the sibship size and other household- and child-specific characteristics, including age.

$$Time_{ijt} = \beta_0 + \beta_1 BO_i + \beta_2 FS_j + \beta_3 T2_t + \beta_4 \mathbf{X}_{ijt} + \beta_5 \mathbf{X}_i + \beta_6 \mathbf{Z}_j + \epsilon_{ijt}$$

where the dependent variable $Time_{ijt}$ stands for the quality time the child receives from the mother observed at each period t of a child i born in family j; BO_i is the set of dummy variables indicating the birth order position of the child; FS_j is the set of dummy variables indicating the number of children born to the parent; $T2_t$ is a dummy variable that indicates the period of observation (i.e. 2007 versus 2002); $\mathbf{X}_{ijt}$ is a vector of child-

and household-specific time-varying characteristics such as the child's age; $\mathbf{X}_i$ stands for the observable individual variables including child's birth weight, race, gender, and maternal childbirth age; and $\mathbf{Z}_j$ is a vector of household-specific characteristics including family size, parental years of education, and parental employment status. Indices denote the observation characteristics - child (i), household (j), and year (t).

Table 1 shows the OLS results, wherein a negative and significant relationship exists between birth order and maternal quality time, with the magnitudes increasing with higher birth order positions. Compared to the first-born counterparts, second-born children receive an average of 2.22 hours per week less maternal quality time, holding other things constant, including the children's respective ages. Third-born children receive 4.06 weekly hours less than their first-born counterparts, while fourth-born and fifth-born children receive 5.42 weekly hours less. The family size dummy variables, although positive, are not statistically significant.

[Table 1 near here]

The negative correlation between maternal quality time and birth order for each point in time disproves Price's (2008) equity heuristic hypothesis. It is not (only) the cumulative amount of parental time that displays a negative birth order pattern, but the time at each and any period as well. This motivates the choice of the maternal quality time received in single period as the relevant input measure in the child outcome equation.

3.2 *The child outcome equation*

The results of the previous section show that children with higher birth order positions receive less maternal quality time, and establish the existence of inequality in the intrahousehold allocation of resources. In order to investigate the role of the particular resource represented by maternal quality time in determining birth order effects, the empirical framework is a reduced-form child production function model, in which past and current child and family characteristics, and input measures, produce the child test score

output (see Todd and Wolpin 2007). The test outcomes are observed in 2002 and 2007 and include letter word, passage comprehension, applied problem, and behavioral problem index. Family characteristics are child's age[1], family size[2], maternal childbirth age, maternal education level in number of years, and maternal employment status. Child characteristics are birth weight[3], race, and gender. Birth order variables are inserted on the right-hand side of the equation, together with the quality time input in a "horse race" regression to test for the extent to which time input explains the birth order effects:

$$Test_{ijt} = \beta_0 + \beta_1 BO_i + \beta_2 FS_j + \beta_3 Time_{it-1} + \beta_4 T2_t + \beta_5 \mathbf{X}_{ijt} + \beta_6 \mathbf{X}_i + \beta_7 \mathbf{Z}_j + \epsilon_{ijt}$$

The dependent variable $Test_{ijt}$ stands for the different test outcomes observed at each period t of a child i born in family j; BO_i, FS_j, $T2_t$, $\mathbf{X}_{ijt}$, $\mathbf{X}_i$, $\mathbf{Z}_j$ are as previously defined. The time input is measured as the parental quality time received at the previous period, $Time_{it-1}$.[4]

A parallel model considers an alternative categorization of birth order position of the child ($BOFS_i$). This variation factors in the family-specific birth order position of a child in his own family.This which in principle "internalizes" the family size effect into the birth order effect by differentiating the birth order positions of different family sizes. For instance, a second-born of a 2-children family is differentiated from the second-borns of the 3-children and of the 4-to-5-children families.

The controls used include birth weight and race, which may be highly correlated with

[1]Both a quadratic functional form for age and a set of age dummy variables were estimated, but the first specification was retained for parsimony purposes, since the results on the coefficients of interest kept unchanged.

[2]The resource dilution hypothesis suggests that resources are "diluted" with more children born into a family, hence leading to poorer outcomes.

[3]This might be highly correlated with family size and birth order. For instance, a latter-born child from a larger family size will more likely have a lower birth weight due to being born to an older mother (Rosenzweig and Zhang 2009)t

[4]The lagged measurement of the input is preferred over the contemporaneous one, to mitigate the issue of simultaneity that may arise in regressing a contemporaneous outcome on a contemporaneous input.

family size and birth order. For instance, a latter-born child from a larger family size will more likely have a lower birth weight due to being born to an older mother (Rosenzweig and Zhang 2009). Using the family size variable is in line

$$Test_{ijt} = \beta_0 + \beta_1 BOFS_i + \beta_3 Time_{it-1} + \beta_4 T2_t + \beta_5 \mathbf{X}_{ijt} + \beta_6 \mathbf{X}_i + \beta_7 \mathbf{Z}_j + \epsilon_{ijt}$$

In both models, ϵ_{ijt} is a three-way errror component:

$$\epsilon_{ijt} = \alpha_i + \psi_{j(t)} + \rho_{ijt}$$

including child-specific time-constant unobserved heterogeneity (α_i), household-specific unobserved heterogeneity that is possibly time-varying ($\psi_{j(t)}$), and an idiosyncratic heterogeneity component (ρ_{ijt}).

The following versions are then estimated:

1. **Pooled OLS**, where $\mathbf{X}_{ijt}$ and all the inputs are assumed to be orthogonal to α_i and $\psi_{j(t)}$, using the above-mentioned models

2. **Sibling Difference** that assumes $\epsilon_{ijt} = \alpha_i + \psi_j + \rho_{ijt}$, i.e. time-constant family unobserved heterogeneity, which is useful to identify birth order and time use variable effects net of unobserved family-specific components, while the child-specific unobserved heterogeneity are assumed to be orthogonal to the inputs:

$$\Delta_j Test_{it} = \beta_1 \Delta_j BO_i + \beta_3 \Delta_j Time_{it-1} + \beta_4 \Delta_j T2_t + \beta_5 \Delta_j \mathbf{X}_{ijt} + \beta_6 \Delta_j \mathbf{X}_i + \Delta_j \epsilon_{ijt}; \quad (1a)$$

$$\Delta_j Test_{it} = \beta_1 \Delta_j BOFS_i + \beta_3 \Delta_j Time_{it-1} + \beta_4 \Delta_j T2_t + \beta_5 \Delta_j \mathbf{X}_{ijt} + \beta_6 \Delta_j \mathbf{X}_i + \Delta_j \epsilon_{ijt} \quad (1b)$$

3. **Time-and-Sibling Difference** assumes $\epsilon_{ijt} = \alpha_i + \psi_j * t + \rho_{ijt}$, i.e. family-specific unobserved heterogeneity evolves with a linear trend, and removes time-constant child- and family-specific characteristics, which is used only to identify the time use

variable effect, since birth order does not vary across time:

$$\begin{aligned} \Delta_t Test_{ij} &= \beta_3 \Delta_t Time_{ij} + \beta_4 \Delta_t T2_t + \beta_5 \Delta_t \mathbf{X}_{ijt} + \Delta_t \epsilon_{ijt}; \\ \Delta_j \Delta_t Test_i &= \beta_3 \Delta_j \Delta_t Time_i + \beta_5 \Delta_j \Delta_t \mathbf{X}_{ijt} + \Delta_j \Delta_t \epsilon_{ijt} \end{aligned} \tag{2}$$

3.2.1 *Dependent Variables*

There are seven children outcomes explored here: three cognitive outcomes in both raw and age-standardized formats and one non-cognitive outcome. Raw scores are essentially the number of items completed in the test, capturing an absolute measure of knowledge that is comparable across children of different ages. The corresponding standardized scores are based on the raw scores, "standardized" according to the respondent's age. The cognitive measures are test components in the Woodcock Johnson Revised (WJ-R) Test of Achievement. Verbal outcomes are measured by the letter word and passage comprehension test components. The letter word test assessment measures symbolic learning (matching pictures with words) and reading identification skills (identifying letters and words). It starts from the easiest items (identification of letters and pronunciation of simple words), progressing to the more difficult items, such that college students and adults would start on a different item than do pre-school children. The passage comprehension assessment measures comprehension and vocabulary skills using multiple-choice and fill-in-the-blank formats. The applied problem test measures mathematical skill in analyzing and solving practical problems in mathematics. The non-cognitive outcome is a behavioral problem index measuring the incidence and severity of child behavior problems, according to the responses of the primary caregiver. While there are two components to the index - externalizing and internalizing, only the total raw score is considered here.

3.2.2 *Maternal Quality Time*

The PSID-CDS provides detailed information on children's time use on a random representative weekday and a random representative weekend. Information is available for up

to two children in a family, specifying the type of activity performed, the amount of time spent on each activity over a 24-hour period, and the company involved in performing the activity (i.e. 'Who was doing this activity with the child?', 'Who (else) was there but not directly involved in the activity?'). Parental time is believed to be a crucial input for a child's outcome (Price 2008), and the available literature have looked at various definitions and measurements, e.g. Hsin (2007) looked at time in terms of total quantity, active engagement, and selected activities. Although both parental times are important in the children's development process and are both separately explored by Price (2008), the literature have emphasized on maternal time, largely due to the increasing incidence of maternal employment that serves as a trade-off for child care time. For this reason, the research focuses on maternal quality time, though similar results are found for paternal time[5]. For the sake of comparability, specific activities performed with the parents are selected to replicate "quality time" as defined by Price (2008). "Quality time" is composed of activities that the children perform with each parent, in which either the child was the primary focus of the activity or there was a reasonable amount of interaction.

Table 2 lists the categories of activities as defined by Price (2008), as well as the average hour spent on each category on a representative weekday and on a representative weekend. The categories are the quality time activities of reading, playing, doing homework, talking, teaching, doing arts and crafts; eating; playing sports, attending performing arts, visiting museums, attending religious practices; and looking after and physical care. The average amount of time mothers spend with their children are higher during the weekends throughout the three waves. In 1997, engaged time is more than non-engaged (around) time, which slowly transition to the opposite pattern as the children get older (second and third waves). Attending performing arts and participating in religious practices are among the most commonly engaged activities, while non-sport playing is one of the most commonly performed activity by the child with the mother

[5]Analysis of paternal time uses information with respect to fathers, i.e. birth order and number of children according to the father. Results are available upon request. Meanwhile, a specification of combining both parents is problematic, as information from the parents may not coincide, e.g. a child can be considered a second-born from the mother, but a first-born from the father.

around but not participating. There is also a significant difference between the second and third waves for certain activities such as "helping with homework" and "talking with, listening to" which is likely due to the aging of the chilren. For ease of interpretation, quality time is aggregated into a weekly measure, derived by multiplying the weekday amount by five, multiplying the weekend amount by two, and getting the summation of the two products.

[Table 2 near here]

3.2.3 *Maternal Characteristics*

Maternal characteristics include (1) maternal age at childbirth, (2) maternal marital status at childbirth, (3) mother's completed years of education in the previous period, (4) maternal lagged employment status, and (5) total number of children born to the mother as of 1997. These characteristics are correlated with birth order, conditional on child cohort and mother cohort.

The time diary methodology used in this research provides better approximation of maternal time with children, than do proxies such as maternal employment status or work hours per week. The latter has been found to have ambiguous effects on children outcomes (Blau and Grossberg 1992; James-Burdumy 2005), due to the fact that maternal non-working time is not necessarily entirely spent with the children. Using maternal employment and work hours as measures provide biased estimates if the employed mothers are able to provide similar amounts of quality time. For instance, employed mothers may compensate for work hours by spending more of their available time with their children and less time on other activities such as leisure (Huston and Aronson 2005). Time diary measures help disentangle the work hours from the actual time spent with the children.

3.2.4 *Child-Specific Characteristics*

Child-specific characteristics include birth weight, age, sex, and a dummy variable for black race. Male children generally have lower verbal and reading achievement test scores,

hence an expected negative correlation with letter word and passage comprehension test scores. Non-white children are also expected to score lower than white children. The crucial variable of analysis is birth order, which is related to initial endowments such as innate cognitive ability, health, and physical development, which may result to different responses from mothers and might be related to current time inputs. Birth order is measured in two ways: (1) as straighforward dummy variables, i.e. second-born, third-born, etc., with the first-born as benchmark and controlling for family size with a similar set of dummy variables, and (2) as family-specific position, i.e. second of two children, first of three children, second of three children, etc., with the first-born children as the benchmark. The latter measure considers the relative birth order position of the child in his respective family, which is more specific than the first measurement.

4 Results

4.1 *Descriptive Analysis*

The analysis uses a pooled sample consisting of 533 PSID-CDS sibling-pair children (1066 children) from 5 to 18 years old, with the average at 12 years, who are living in intact families[6] of two to five children. The summary statistics of the relevant variables for 2002, 2007, and the full sample are shown in Table 3. Half of the sample are males, and 18% are Blacks. First-born children occupy 36% of the sample, second-borns comprise 43%, third-borns are 17%, and 4th- and 5th-borns are 5%. Meanwhile, the pooled sample has an average of 2.8 children in the family. Almost half of the sample are 2-children families, at 42%, 41% are 3-children families, 17% are families with 4 to 5 children. The distribution of ages by birth order positions are shown in the graphs in the Appendix, showing that the sample contains variation in ages in each birth order position, an important requirement not to confuse birth order effects for age effects.

[6]Intact families are two-parent households, wherein parents and children are biologically related to each other.

[Table 3 near here]

The letter word standardized score of the pooled sample averages at 106.73 with a standard deviation of 16.90 points, while the raw test score averages at 44.69, with a standard deviation of 8.46 points. The sample average of the passage comprehension standardized score is at 105.66, with a standard deviation of 15.40 points, while the raw score averages at 26.26, with a standard deviation of 6.76. Applied problem averages at 107.20 and 38.14 for standardized and raw, with standard deviations of 15.97 and 8.11, respectively. The behavioral problem index averages at 13.87, with a standard deviation of 11.02.

If the observed outcome of each child in a family is thought of as including an error term with individual-specific and family-specific components, the variance of this term can be decomposed into between-family and within-family variations. The sibling correlation coefficients of the test scores and maternal quality time for interviewed sibling pairs shown in the first two columns of Table 4 correspond to the share of variance that is attributable to the family background effects. The higher the sibling correlation coefficients, the higher is the share of the variance that is due to the family-specific components. The sibling correlations for the standardized test scores in 2002 and 2007 are approximately between 0.42 to 0.54, while that for the raw scores are between 0.28 to 0.53. The sibling correlation of the behavioral problem index is 0.35 and 0.24 for 2002 and 2007, respectively. That for lagged maternal quality times are at 0.64 and 0.62. The last two columns of the same table show the proportion of total variation that is "explained" by the differences in sibling groups, the within family variation, also for both 2002 and 2007. This provides evidence on variation within the family for the validity of using a sibling difference approach.

[Table 4 near here]

Figures 2 and 3 exhibit the average test scores measured in 2002 and 2007 for each birth order position. That for 2002 clearly shows a decreasing pattern of average test scores for each higher birth order position, while that for 2007 is more ambiguous. The

increasing pattern seen in Figure 2 for the non-cognitive test score implies that children with higher birth order positions have more behavioral problems, on the average, than do children with lower birth order positions. Meanwhile, only the letter word shows a clear declining pattern, while that for passage comprehension shows a general decreasing pattern except for the second-born. The ambiguous patterns of the non-cognitive outcome and applied problem might suggest an underlying issue with using a pooled dataset for analysis of these outcomes. Birth order effects particularly for the behavioral problem index are expected to be inconclusive also because of the nature of its measurement. Unlike the cognitive test scores, which are objectively evaluated, the behavioral problem index is derived from a subjective evaluation of the child's behavior by the primary caregiver.

[Figures 2 and 3 near here]

Table 5 shows the average standardized test scores by the amount of maternal quality time received. The sample is divided into two groups, based on the average quality time of the sample: those who received greater than the average and those who received less than or equal to the average quality time. It is evident that receipt of maternal quality time greater than the average is associated with better performance in the test outcomes. The differences are statistically significant only for the cognitive test scores, as shown by the mean comparison tests, with particularly strong evidence for the verbal outcomes. The result on the behavioral problem index are only shown for the sake of completeness; care must be taken in doing the analysis and interpretation for this outcome.

[Table 5 near here]

4.2 *Does Maternal Quality Time Explain Birth Order Effects?*

To test for birth order effects, measurements of children outcomes are estimated on birth order and family size, controlling for child-specific characteristics and the quality of household resources available. Maternal quality time is then included in a horse race regression

to look at its role in explaining birth order effects. The children outcomes are first estimated using OLS, with standard errors corrected for the correlation of error terms among siblings.

Tables 6 to 9 show the estimation results for the four outcomes, namely letter word, passage comprehension, applied problem, and behavioral problem index using straightforward birth order and family size dummy variables, with the first-borns and 2-children families as the benchmark. The appendix contains the results for the specifications with the family-specific birth order positions of each child, with the first-borns as the benchmark. The cognitive tests show both standardized and raw scores, the former on the left half of the tables and the raw scores on the right half. Each column shows the result for a different model specification. The first two columns are of a standard pooled OLS on interviewed sibling pairs, excluding and including lagged maternal quality time. This should be comparable to the sibling difference approach on the next two columns, again excluding and including maternal quality time. The last column is of the second step in a time-and-sibling difference approach, used to reinforce the result on the variable maternal quality time, after having removed time-constant child- and household-specific unobservables. It is important to note that the interpretation of the results on the non-cognitive measure of Behavioral Problem Index must be done with care, as it may require a different production function to that of cognitive outcomes.

[Tables 6 to 9 near here]

Using a pooled OLS estimation, the birth order variables exhibit statistically significant negative patterns, with the magnitudes increasing for each higher birth order position. Including the lagged maternal quality time that shows a positive and statistically significant coefficient only for the letter word outcome decreases the magnitudes of the negative birth order variables, implying that maternal quality time is an important variable to include in the regression, else risk misspecification. Likewise, the magnitudes of the negative birth order effects are "bloated" when maternal quality time is not accounted for. This is true for both standardized and raw scores of the cognitive outcomes

of the interviewed sibling pairs. The noncognitive outcome shows an initial family size effects, given the non-significant coefficients of the birth order variables and the positive and statistically significant coefficients of the family size dummy variables. This suggests that children from larger families have more behavioral problems. A child from a 3-children family, for instance, score 0.71 additional points on BPI compared to his counterpart from a 2-children family, holding other things constant.

OLS estimations are however criticized to provide biased estimates. With respect to birth order and family size, unmeasured parental endowments and family size preferences are potential sources of unobserved heterogeneity affecting child development outcomes. If parents with below-average resources also have fewer children, then children with lower birth order positions are more likely to have poorer outcomes compared to their counterparts. The opposite is also true, if parents with above-average resources prefer to have children of better abilities by foregoing a larger family size. To account for unobserved household-specific characteristics that may contribute to the bias, a sibling-difference approach is employed. The results show a similar negative and increasing magnitude pattern for the birth order variables, particularly for the raw scores. This is true for both categorization of birth order positions. In fact, results with family-specific birth order variables show negative birth order effects in smaller families. Including the lagged maternal quality time as a regressor does not change the coefficients of the negative birth order variables. Moreover, the maternal quality time variable is no longer statistically significant, rejecting the idea that maternal quality time is an important determinant for children outcomes, once time-constant family-specific unobserved heterogeneity are controlled for. To emphasize the result on maternal quality time, a time-and-sibling difference approach is employed. After the second-step difference, only the age squared and maternal quality time variables are left among the regressors, and the latter variable shows a positive but non-significant coefficient. Employing a sibling difference approach on the non-cognitive outcome proves that the significance of the coefficients of family size variables in the pooled OLS is driven by confounding birth order with family size.

Differencing the family-specific characteristics shows the underlying negative "birth order effects," such that higher birth order children have more behavioral problems. [7]

In summary, pooled OLS results show negative and statistically significant coefficients for the birth order variables, with the magnitudes slightly diminishing with the inclusion of the maternal quality time in the regression. This suggests the importance of the latter variable in determining children outcomes, as suggested in the literature. However, once family effects are controlled for, maternal quality time loses its significance in determining children outcomes, but the coefficients of birth order variables remain negative and statistically significant. This suggests that birth order effects do not mask differences in maternal quality time received, and disproves Price (2008) in suggesting that parental time is a crucial input for a child's educational outcome. Although the research also finds a negative birth order effect in parental quality time, as Price (2008), this research does not find the same result of equal amounts of parental time with children at a given point of time.

5 Conclusions

Children of higher birth order positions are found to have poorer outcomes. Literature suggests that inequalities in children outcomes based on the respective birth order positions could be due to differences in resources received. This paper focuses on the role of a particular resource received from parents - maternal quality time. It investigates whether birth order effects in children outcomes are due to differences in quality time received, by looking at the relationship between children's birth order position, maternal quality time input, and children's cognitive and non-cognitive outcomes.

Using data from the Child Development Supplement of the Panel Study of Income Dynamics, the initial OLS results confirm the negative relationship between birth order

[7] As a robustness check, specifications that use both lagged and contemporaneous maternal quality time were also estimated for all outcomes, with only the lagged measurement being statistically significant using OLS estimations. As with the cases presented above, the coefficient loses its significance with the application of the sibling difference approach.

and all the available test scores, which is consistent with the findings of Black, Devereux, and Salvanes (2007), Kantarevic and Mechoulan (2005), and Heiland (2009), among others. A negative relationship is found between birth order and maternal quality time, partly consistent with Price (2008). When maternal quality time is added among the children outcome determinants, its coefficient is found to be positive but statistically significant only for letter word test, while the coefficient of the birth order variables keeps negative and statistically significant.

Within a sibling difference approach removing bias arising from unobserved household-specific heterogeneity, the negative birth order effects are confirmed for both cognitive and non-cognitive outcomes, while maternal quality time coefficients lose any significance. These results suggest that maternal quality time is not the driving factor behind birth order effects. To the extent that birth order effects are the outcome of the mechanism of intrahousehold allocation of resources, they must be explained by other resources differently allocated to each offspring.

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Table 1: **OLS Results for Maternal Quality Time**

Variables	**Time**
$BO2$	-2.22***
	(0.67)
$BO3$	-4.06***
	(1.25)
$BO45$	-5.42**
	(2.24)
$FS3$	0.81
	(1.03)
$FS45$	2.47
	(1.71)
$Constant$	43.49***
	(4.19)
R^2	0.3989
N	1062
Controls	Child, Family, T2

Child controls include child's age, child's age squared, birth weight, gender, dummy variable for black race. Family controls include mother's age at childbirth, mother's education level in years, and mother's employment status. Standard errors are shown in parentheses, followed by indicators of significance levels (*** significant at 1% level, ** significant at 5% level, * significant at 10% level).

Table 2: **Hourly Averages of Maternal Quality Time Activities**

	1997		**2002**		**2007**	
Weekday	Engaged	Around	Engaged	Around	Engaged	Around
Reading	0.19	0.15	0.14	0.24	0.68	0.66
Playing, not sports	0.14	0.35	0.07	0.35	0.91	0.95
Helping with homework	0.23	0.31	0.21	0.21	0.96	0.8
Talking with, Listening to	0.15	0.12	0.1	0.23	0.38	0.76
Helping, Teaching	0	0.02	0.02	0.13		0.35
Arts and crafts	0.1	0.24	0.09	0.21	0.48	0.81
Eating	0.23	0.1	0.24	0.08	0.46	0.31
Playing sports	0.13	0.23	0.07	0.15	0.91	0.6
Attending performing arts	1.35	0.1	0.6	0	1.04	
Attending museums	0.44	0	0.06	0		
Participating in religious practices	0.35	0.05	0.27	0.06	1.37	0.57
Looking after, physical care	0.2	0.03	0.01	0.01	0.01	0.01
Quality Time	0.19	0.17	0.06	0.07	0.08	0.13
Weekend	Engaged	Around	Engaged	Around	Engaged	Around
Reading	0.18	0.21	0.13	0.33	0.67	0.79
Playing, not sports	0.16	0.42	0.08	0.45	1.04	1.13
Helping with homework	0.21	0.37	0.35	0.13	0.98	0.93
Talking with, Listening to	0.16	0.14	0.12	0.25	0.55	0.79
Helping, Teaching	0	0.33	0	0.04		0.53
Arts and crafts	0.1	0.28	0.13	0.27	0.6	0.64
Eating	0.29	0.1	0.3	0.09	0.53	0.38
Playing sports	0.17	0.3	0.12	0.23	0.75	0.71
Attending performing arts	1.09	0.01	0.67	0.04	1.5	3.08
Attending museums	1.01	0	1.53	0.2	0.63	
Participating in religious practices	0.75	0.12	0.79	0.12	1.92	1.14
Looking after, physical care	0.25	0.04	0.01	0.01	0.13	0.01
Quality Time	0.24	0.21	0.12	0.12	0.17	0.21

Table 3: **Summary Statistics**

Variables	**2002** (Std.Dev.)	**2007** (Std.Dev.)	**Overall** (Std.Dev.)
Child's age	10.97	13.18	11.61
	(3.35)	(2.02)	(3.19)
Child's gender (Male=1)	0.49	0.51	0.49
Child's race (Black=1)	0.18	0.18	0.18
Child's birth weight, pounds	7.15[8]	7.02[9]	7.11
	(1.25)	(1.37)	(1.29)
Mother's age at childbirth	28.23	28.15	28.21
	(5.01)	(5.54)	(5.16)
Lagged maternal education in years	13.35	13.44	13.38
	(2.49)	(2.58)	(2.52)
Lagged maternal employment status (Employed=1)	0.60	0.61	0.60
1st-born (BO1)	0.34	0.38	0.36
2nd-born (BO2)	0.43	0.45	0.43
3rd-born (BO3)	0.18	0.14	0.17
4th-5th born (BO45)	0.05	0.03	0.05
Sibship size	2.80	2.75	2.79
	(0.83)	(0.80)	(0.82)
2-children families (FS2)	0.42	0.44	0.42
3-children families (FS3)	0.40	0.42	0.41
4-5 children families (FS45)	0.18	0.11	0.17
1st of 2 children (BO1FS2)	0.21	0.22	0.21
2nd of 2 children (BO2FS2)	0.21	0.22	0.21
1st of 3 children (BO1FS3)	0.10	0.13	0.11
2nd of 3 children (BO2FS3)	0.17	0.19	0.18
3rd of 3 children (BO3FS3)	0.14	0.11	0.12
1st of 4-5 children (BO1FS45)	0.03	0.04	0.03
2nd of 4-5 children (BO2FS45)	0.04	0.05	0.04
3rd of 4-5 children (BO3FS45)	0.05	0.03	0.05
4th-5th of 4-5 children (BO45FS45)	0.05	0.03	0.04
Letter word standardized score (LWSS)	107.26	105.44	106.73
	(17.31)	(15.82)	(16.90)
Letter word raw score (LWRAW)	43.51	47.60	44.69
	(9.17)	(5.39)	(8.46)
Passage comprehension standardized score (PCSS)	107.30	101.63	105.66
	(15.10)	(15.40)	(15.40)
Passage comprehension raw score (PCRAW)	25.47	28.19	26.26
	(7.19)	(5.06)	(6.76)
Applied problem standardized score (APSS)	106.10	107.44	107.20
	(16.32)	(15.12)	(15.97)
Applied problem raw score (APRAW)	36.99	40.96	38.14
	(8.48)	(6.30)	(8.11)
Behavioral problem index (BPI)	7.68	29.11	13.87
	(6.02)	(2.11)	(11.02)
Lagged maternal quality time ($QualT_{t-1}$)	26.68	15.51	23.45
	(15.22)	(9.44)	(14.70)
Number of observations	758	308	1066

Table 4: **Sibling Correlations and Variations in the Differences of the Sibling Group Means**

	Sibling Correlations		Variations	
Variables	**2002**	**2007**	**2002**	**2007**
Letter Word Std.	0.5417	0.5179	0.7704***	0.7578***
Letter Word Raw	0.2843	0.5149	0.6415***	0.7563***
Passage Comprehension Std.	0.4235	0.5242	0.7112***	0.7609***
Passage Comprehension Raw	0.3166	0.5004	0.6577***	0.7490***
Applied Problem Std.	0.4478	0.4714	0.7234***	0.7346***
Applied Problem Raw	0.4203	0.4341	0.7096***	0.7157***
Behavioral Problem Index	0.3507	0.2365	0.6748***	0.6167**
Lagged Maternal Quality Time	0.6427	0.6155	0.8209***	0.8067***
Number of observations	758	308	758	308

Table 5: **Average Standardized Scores by Maternal Quality Time**

$Test_{2002}$	**Letter Word**	**Passage Comp**	**Applied Prob**	**Behavior**
$<= AveTime_{97}$	105.30	104.48	105.62	8.18
$> AveTime_{97}$	109.71	110.82	108.95	7.05
Mean Comparison Test	-4.41***	-6.35***	-3.33**	1.13**
	(1.26)	(1.08)	(1.19)	(0.44)
$Test_{2007}$	**Letter Word**	**Passage Comp**	**Applied Prob**	**Behavior**
$<= AveTime_{02}$	102.17	99.36	106.14	29.20
$> AveTime_{02}$	109.35	104.35	108.99	29
Mean Comparison Test	-7.18***	-4.99**	-2.84**	0.20
	(1.77)	(1.74)	(1.73)	(0.24)

Table 6: **Regression Results for Letter Word Test Scores**

	Standardized Scores					**Raw Scores**				
	Pooled OLS, siblings		**Sibling Difference**		**Double Diff**	**Pooled OLS, siblings**		**Sibling Difference**		**Double Diff**
	BO	**BO+Time**	**BO**	**BO+Time**	**Time**	**BO**	**BO+Time**	**BO**	**BO+Time**	**Time**
$BO2$	-3.68***	-3.48***	-2.51*	-2.48*		-1.18***	-1.11***	-1.11**	-1.10**	
	(1.16)	(1.16)	(1.44)	-1.44		(0.37)	(0.37)	(0.56)	(0.56)	
$BO3$	-6.58***	-6.15***	-4.00	-3.94		-2.36***	-2.22***	-2.34**	-2.33**	
	(1.68)	(1.67)	(2.74)	-2.73		(0.59)	(0.58)	(1.07)	(1.07)	
$BO45$	-11.11***	-10.57***	-4.45	-4.39		-4.41***	-4.23***	-3.63**	-3.62**	
	(3.28)	(3.26)	(4.49)	-4.5		(1.13)	(1.13)	(1.83)	(1.83)	
$FS3$	-0.15	-0.27				-0.24	-0.28			
	(1.41)	(1.40)				(0.43)	(0.43)			
$FS45$	2.03	1.68				0.71	0.59			
	(1.95)	(1.91)				(0.64)	(0.63)			
$QualT_{t-1}$		0.08*		-0.04	0.01		0.03*		-0.01	0.01
		(0.05)		(0.08)	(0.12)		(0.02)		(0.03)	(0.05)
$Constant$	93.07***	87.22***				-14.85***	-16.82***			
	(8.05)	(8.96)				(3.07)	(3.31)			
R^2	0.2029	0.2063	0.0182	0.0188	0.0094	0.6490	0.6505	0.6370	0.6371	0.5360
N	1066	1066	533	533	120	1066	1066	533	533	120
Controls	Child, Family, T2		Child, Family, T2		Child	Child, Family, T2		Child, T2		Child

Child controls include child's age, child's age squared, birth weight, gender, dummy variable for black race. Family controls include mother's age at childbirth, and mother's education level in years. Standard errors are shown in parentheses, followed by indicators of significance levels (*** significant at 1% level, ** significant at 5% level, * significant at 10% level).

Table 7: **Regression Results for Passage Comprehension Test Scores**

	Standardized Scores					**Raw Scores**				
	Pooled OLS, siblings		**Sibling Difference**		**Double Diff**	**Pooled OLS, siblings**		**Sibling Difference**		**Double Diff**
	BO	**BO+Time**	**BO**	**BO+Time**	**Time**	**BO**	**BO+Time**	**BO**	**BO+Time**	**Time**
$BO2$	-2.48**	-2.34**	-2.74*	-2.73*		-1.01***	-0.97***	-1.39***	-1.38***	
	(1.01)	(1.02)	(1.42)	(1.43)		(0.32)	(0.32)	(0.49)	(0.49)	
$BO3$	-5.06***	-4.76***	-4.58*	-4.56*		-1.95***	-1.87***	-2.54***	-2.53***	
	(1.68)	(1.68)	(2.70)	(2.71)		(0.51)	(0.51)	(0.92)	(0.93)	
$BO45$	-5.72*	-5.35*	-5.74	-5.72		-2.25**	-2.15**	-3.13**	-3.12**	
	(3.14)	(3.16)	(4.25)	(4.26)		(1.03)	(1.04)	(1.49)	(1.49)	
$FS3$	-0.26	-0.35				-0.12	-0.15			
	(1.20)	(1.20)				(0.37)	(0.37)			
$FS45$	0.49	0.25				0.06	-0.01			
	(1.68)	(1.65)				(0.53)	(0.53)			
$QualT_{t-1}$		0.06		-0.01	0.14		0.02		-0.01	0.06
		(0.04)		(0.07)	(0.11)		(0.01)		(0.02)	(0.04)
$Constant$	102.00***	97.95***				-16.78***	-17.96***			
	(7.49)	(8.27)				(2.56)	(2.78)			
R^2	0.2338	0.2358	0.0438	0.0438	0.056	0.5936	0.5944	0.5511	0.5512	0.4118
N	1066	1066	533	533	120	1066	1066	533	533	120
Controls	Child, Family, T2		Child, T2		Child	Child, Family, T2		Child, T2		Child

Child controls include child's age, child's age squared, birth weight, gender, dummy variable for black race. Family controls include mother's age at childbirth, and mother's education level in years. Standard errors are shown in parentheses, followed by indicators of significance levels (*** significant at 1% level, ** significant at 5% level, * significant at 10% level).

Table 8: **Regression Results for Applied Problem Test Scores**

	Standardized Scores					**Raw Scores**				
	Pooled OLS, siblings		**Sibling Difference**		**Double Diff**	**Pooled OLS, siblings**		**Sibling Difference**		**Double Diff**
	BO	**BO+Time**	**BO**	**BO+Time**	**Time**	**BO**	**BO+Time**	**BO**	**BO+Time**	**Time**
$BO2$	-1.77*	-1.80*	-2.12	-2.11		-0.98***	-0.97***	-1.49***	-1.48***	
	(0.94)	(0.93)	(1.57)	(1.58)		(0.35)	(0.35)	(0.55)	(0.55)	
$BO3$	-2.77	-2.82*	-4.08	-4.06		-1.27**	-1.25**	-2.45**	-2.44**	
	(1.69)	(1.68)	(3.10)	(3.12)		(0.61)	(0.61)	(1.09)	(1.09)	
$BO45$	-1.87	-1.93	-4.38	-4.36		-0.24	-0.22	-1.92	-1.91	
	(2.51)	(2.51)	(4.64)	(4.65)		(0.90)	(0.90)	(1.65)	(1.66)	
$FS3$	-1.47	-1.45				-0.47	-0.48			
	(1.24)	(1.24)				(0.44)	(0.44)			
$FS45$	-1.04	-1.00				-0.65	-0.67			
	(2.05)	(2.05)				(0.69)	(0.69)			
$QualT_{t-1}$		-0.01		-0.01	-0.08		0.00		-0.01	-0.03
		(0.04)		(0.08)	(0.11)		(0.01)		(0.03)	(0.03)
$Constant$	59.96***	60.59***				-15.33***	-15.61***			
	(5.89)	(6.92)				(2.10)	(2.49)			
R^2	0.2788	0.2788	0.05080	0.0509	0.0413	0.6430	0.6430	0.5470	0.5471	0.4457
N	1066	1066	533	533	120	1066	1066	533	533	120
Controls	Child, Family, T2		Child, T2		Child	Child, Family, T2		Child, T2		Child

Child controls include child's age, child's age squared, birth weight, gender, dummy variable for black race. Family controls include mother's age at childbirth, and mother's education level in years. Standard errors are shown in parentheses, followed by indicators of significance levels (*** significant at 1% level, ** significant at 5% level, * significant at 10% level).

Table 9: **Regression Results for Behavioral Problem Index**

	Pooled OLS, siblings		**Sibling Difference**		**Double Diff**
	BO	**BO+Time**	**BO**	**BO+Time**	**Time**
$BO2$	0.38	0.32	1.30**	1.30**	
	(0.33)	(0.33)	(0.61)	(0.61)	
$BO3$	0.64	0.52	3.19***	3.18***	
	(0.58)	(0.59)	(1.16)	(1.16)	
$BO45$	0.95	0.79	4.94***	4.93***	
	(1.16)	(1.17)	(1.81)	(1.81)	
$FS3$	0.71*	0.74*			
	(0.39)	(0.39)			
$FS45$	0.49	0.60			
	(0.58)	(0.59)			
$QualT_{t-1}$		-0.02		0.01	-0.02
		(0.02)		(0.02)	(0.04)
$Constant$	9.03***	10.73***			
	(2.67)	(2.92)			
R^2	0.7831	0.7838	0.0320	0.0321	0.0020
N	1066	1066	533	533	120
Controls	Child, Family, T2		Child, T2		Child

Child controls include child's age, child's age squared, birth weight, gender, dummy variable for black race. Family controls include mother's age at childbirth, and mother's education level in years. Standard errors are shown in parentheses, followed by indicators of significance levels (*** significant at 1% level, ** significant at 5% level, * significant at 10% level).

Figure 1: Mean Maternal Time by Birth Order

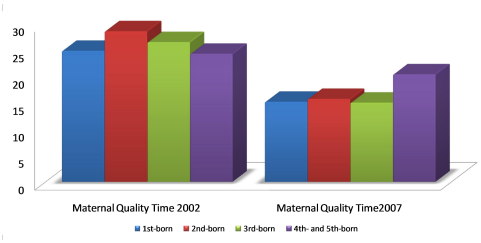


Figure 2: Average Standardized Scores in 2002 by Birth Order

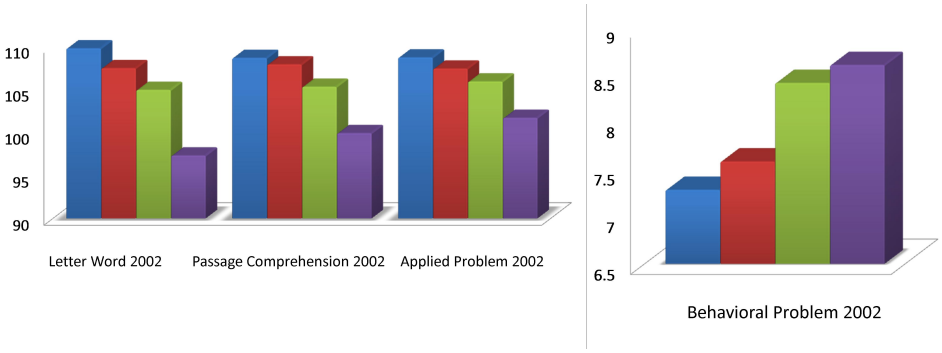
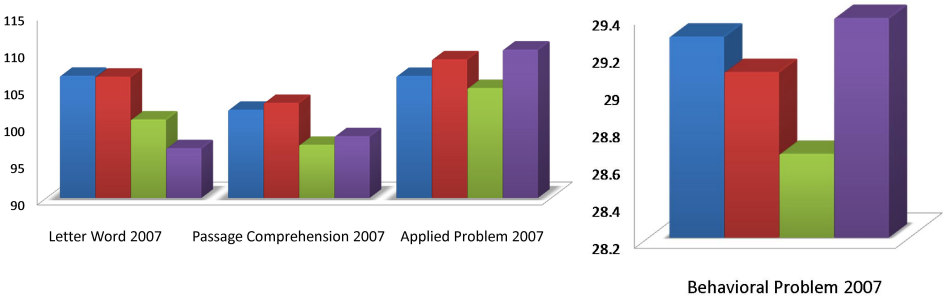


Figure 3: Average Standardized Scores in 2007 by Birth Order



Appendices

A List of Variables

- Test Score
  - Woodcock Johnson-Revised Letter Word (LW) Score, 2002 and 2007
  - Woodcock Johnson-Revised Passage Comprehension (PC) Score, 2002 and 2007
  - Woodcock Johnson-Revised Applied Problem (AP) Score, 2002 and 2007
  - Woodcock Johnson-Revised Behavioral Problem Index (BPI), 2002 and 2007
- Child Characteristics
  - Age in assessment test, 2002 and 2007
  - Race/Ethnicity: Black (dummy variable)
  - Sex: Male or Female (dummy variable)
  - Birth weight, ounces
  - Birth Order: 1st (benchmark), 2nd, 3rd, and 4th-and-5th (dummy variables)
- Maternal Characteristics
  - Mother's age at childbirth in years
  - Mother's marital status at childbirth
  - Sib-ship size; Total number of children born to the mother
  - Mother's total years of completed education, 1997 and 2002
  - Mother's employment status, 1997 and 2002 (dummy variable)
- Quality Time

– Weekly maternal quality time approximated by: (quality time on a representative weekday x 5) + (quality time on a representative weekend x 2)

B Tables

Table B.1: **Regression Results for Letter Word Test Scores**

	Standardized Scores					**Raw Scores**				
	Pooled OLS, siblings		**Sibling Difference**		**Double Diff**	**Pooled OLS, siblings**		**Sibling Difference**		**Double Diff**
	BO	**BO+Time**	**BO**	**BO+Time**	**Time**	**BO**	**BO+Time**	**BO**	**BO+Time**	**Time**
$BO2FS2$	-3.79***	-3.47***	-2.96*	-2.97*		-1.12**	-1.01**	-1.09*	-1.09*	
	(1.28)	(1.28)	(1.58)	(1.59)		(0.43)	(0.43)	(0.62)	(0.62)	
$BO2FS3$	-3.70**	-3.57**	-1.27	-1.19		-1.38***	-1.33**	-1.03	-1.02	
	(1.67)	(1.67)	(2.11)	(2.10)		(0.52)	(0.52)	(0.75)	(0.75)	
$BO3FS3$	-6.62***	-6.19***	-3.62	-3.54		-2.58***	-2.44***	-2.47**	-2.46**	
	(1.80)	(1.80)	(3.07)	(3.07)		(0.63)	(0.64)	(1.15)	(1.15)	
$BO2FS45$	-2.85	-2.97*	-4.62	-4.50		-0.77	-0.81	-1.67	-1.65	
	(1.80)	(1.76)	(3.06)	(3.07)		(0.71)	(0.69)	(1.21)	(1.22)	
$BO3FS45$	-5.22**	-5.15**	-3.20	-3.02		-1.63**	-1.61**	-1.87	-1.84	
	(2.21)	(2.21)	(4.24)	(4.22)		(0.79)	(0.79)	(1.77)	(1.78)	
$BO45FS45$	-9.16***	-8.90***	-4.37	-4.22		-3.68***	-3.60***	-3.41	-3.38	
	(2.83)	(2.81)	(5.03)	(5.05)		(0.99)	(0.99)	(2.15)	(2.15)	
$QualT_{t-1}$		0.09*		-0.05	0.01		0.03*		-0.01	0.01
		(0.05)		(0.08)	(0.12)		(0.02)		(0.03)	(0.05)
$Constant$	94.28***	88.12***				-14.56***	-16.62***			
	(7.75)	(8.71)				(3.02)	(3.26)			
R^2	0.2017	0.2053	0.0219	0.0227	0.0094	0.6484	0.6500	0.6377	0.6378	0.5360
N	1066	1066	533	533	120	1066	1066	533	533	120
Controls	Child, Family, T2		Child, T2		Child	Child, Family, T2		Child, T2		Child

Child controls include child's age, child's age squared, birth weight, gender, dummy variable for black race. Family controls include mother's age at childbirth, and mother's education level in years. Standard errors are shown in parentheses, followed by indicators of significance levels (*** significant at 1% level, ** significant at 5% level, * significant at 10% level).

Table B.2: **Regression Results for Passage Comprehension Test Scores**

	Standardized Scores					**Raw Scores**				
	Pooled OLS, siblings		**Sibling Difference**		**Double Diff**	**Pooled OLS, siblings**		**Sibling Difference**		**Double Diff**
	BO	**BO+Time**	**BO**	**BO+Time**	**Time**	**BO**	**BO+Time**	**BO**	**BO+Time**	**Time**
$BO2FS2$	-1.88	-1.66	-2.06	-2.06		-0.84**	-0.78**	-1.22**	-1.23**	
	(1.15)	(1.16)	(1.52)	(1.52)		(0.37)	(0.37)	(0.53)	(0.53)	
$BO2FS3$	-3.08**	-2.98**	-4.37**	-4.36**		-1.15**	-1.13**	-1.85***	-1.84***	
	(1.40)	(1.40)	(2.05)	(2.05)		(0.45)	(0.46)	(0.67)	(0.67)	
$BO3FS3$	-5.89***	-5.60***	-6.36**	-6.35**		-2.31***	-2.22***	-3.24***	-3.23***	
	(1.69)	(1.68)	(3.08)	(3.10)		(0.53)	(0.53)	(1.01)	(1.02)	
$BO2FS45$	-2.99	-3.07	-1.81	-1.79		-1.36**	-1.38**	-1.16	-1.14	
	(2.03)	(1.99)	(2.28)	(2.28)		(0.65)	(0.64)	(0.85)	(0.86)	
$BO3FS45$	-2.85	-2.80	-1.32	-1.29		-1.17*	-1.15*	-0.86	-0.84	
	(2.31)	(2.30)	(3.55)	(3.59)		(0.69)	(0.68)	(1.35)	(1.37)	
$BO45FS45$	-5.13*	-4.95*	-3.08	-3.06		-2.15**	-2.10**	-1.85	-1.82	
	(2.90)	(2.91)	(4.41)	(4.41)		(0.95)	(0.95)	(1.63)	(1.63)	
$QualT_{t-1}$		0.06		-0.01	0.14		0.02		-0.01	0.06
		(0.04)		(0.07)	(0.11)		(0.01)		(0.02)	(0.04)
$Constant$	102.34***	98.15***				-16.76***	-17.96***			
	(7.35)	(8.18)				(2.53)	(2.76)			
R^2	0.2355	0.2375	0.0485	0.0486	0.0560	0.5947	0.5956	0.5546	0.5547	0.4118
N	1066	1066	533	533	120	1066	1066	533	533	120
Controls	Child, Family, T2		Child, T2		Child	Child, Family, T2		Child, T2		Child

Child controls include child's age, child's age squared, birth weight, gender, dummy variable for black race. Family controls include mother's age at childbirth, and mother's education level in years. Standard errors are shown in parentheses, followed by indicators of significance levels (*** significant at 1% level, ** significant at 5% level, * significant at 10% level).

Table B.3: **Regression Results for Applied Problem Test Scores**

	Standardized Scores					**Raw Scores**				
	Pooled OLS, siblings		**Sibling Difference**		**Double Diff**	**Pooled OLS, siblings**		**Sibling Difference**		**Double Diff**
	BO	**BO+Time**	**BO**	**BO+Time**	**Time**	**BO**	**BO+Time**	**BO**	**BO+Time**	**Time**
$BO2FS2$	-0.92	-0.96	-1.89	-1.89		-0.79*	-0.78*	-1.57***	-1.58***	
	(1.21)	(1.21)	(1.74)	(1.74)		(0.42)	(0.42)	(0.61)	(0.61)	
$BO2FS3$	-2.93**	-2.95**	-3.51	-3.48		-1.23***	-1.23***	-1.75**	-1.73**	
	(1.28)	(1.27)	(2.13)	(2.15)		(0.48)	(0.48)	(0.73)	(0.73)	
$BO3FS3$	-4.10**	-4.15**	-6.33*	-6.30*		-1.76***	-1.74***	-3.16***	-3.14***	
	(1.77)	(1.77)	(3.52)	(3.53)		(0.62)	(0.62)	(1.20)	(1.21)	
$BO2FS45$	-2.80	-2.79	-0.25	-0.21		-1.51**	-1.52**	-0.75	-0.73	
	(2.30)	(2.29)	(2.83)	(2.81)		(0.75)	(0.75)	(1.05)	(1.05)	
$BO3FS45$	-2.24	-2.24	2.17	2.24		-1.22	-1.22	0.10	0.13	
	(2.39)	(2.39)	(4.57)	(4.56)		(0.92)	(0.92)	(1.81)	(1.80)	
$BO45FS45$	-2.38	-2.41	0.56	0.62		-0.71	-0.70	0.05	0.09	
	(1.74)	(1.75)	(5.08)	(5.08)		(0.68)	(0.68)	(1.92)	(1.92)	
$QualT_{t-1}$		-0.01		-0.02	-0.08		0.00		-0.01	-0.03
		(0.04)		(0.08)	(0.11)		(0.01)		(0.03)	(0.03)
$Constant$	58.95***	59.64***				-15.93***	-16.15***			
	(5.83)	(6.83)				(2.14)	(2.52)			
R^2	0.2794	0.2795	0.0586	0.0587	0.0413	0.6428	0.6428	0.5514	0.5515	0.4457
N	1066	1066	533	533	120	1066	1066	533	533	120
Controls	Child, Family, T2		Child, T2		Child	Child, Family, T2		Child, T2		Child

Child controls include child's age, child's age squared, birth weight, gender, dummy variable for black race. Family controls include mother's age at childbirth, and mother's education level in years. Standard errors are shown in parentheses, followed by indicators of significance levels (*** significant at 1% level, ** significant at 5% level, * significant at 10% level).

Table B.4: **Regression Results for Behavioral Problem Index**

	Pooled OLS, siblings		**Sibling Difference**		**Double Diff**
	BO	**BO+Time**	**BO**	**BO+Time**	**Time**
$BO2FS2$	0.18	0.09	1.42**	1.42**	
	(0.40)	(0.40)	(0.67)	(0.67)	
$BO2FS3$	0.55	0.52	0.97	0.95	
	(0.41)	(0.41)	(0.72)	(0.73)	
$BO3FS3$	1.46**	1.34**	2.98**	2.97**	
	(0.59)	(0.60)	(1.20)	(1.20)	
$BO2FS45$	1.65**	1.68**	1.78	1.76	
	(0.75)	(0.75)	(1.14)	(1.15)	
$BO3FS45$	0.00	-0.02	3.36*	3.34*	
	(0.89)	(0.89)	(1.74)	(1.74)	
$BO45FS45$	1.19	1.12	5.18**	5.16**	
	(1.10)	(1.10)	(2.02)	(2.02)	
$QualT_{t-1}$		-0.02		0.01	-0.02
		(0.02)		(0.02)	(0.04)
$Constant$	9.50***	11.21***			
	(2.66)	(2.92)			
R^2	0.7837	0.7843	0.0333	0.0334	0.0020
N	1066	1066	533	533	120
Controls	Child, Family, T2		Child, T2		Child

Child controls include child's age, child's age squared, birth weight, gender, dummy variable for black race. Family controls include mother's age at childbirth, and mother's education level in years. Standard errors are shown in parentheses, followed by indicators of significance levels (*** significant at 1% level, ** significant at 5% level, * significant at 10% level).

Table B.5: Results of Second Difference Using Time-and-Sibling Difference

	Standardized			Raw			
Variables	**Letter Word**	**Passage Comp**	**Applied Prob**	**Behavior**	**Letter Word**	**Passage Comp**	**Applied Prob**
$BO2FS2 * T2$	3.01	2.26	-5.98*	-0.16	2.89*	2.13*	-1.28
	(3.44)	(3.61)	(3.57)	(1.31)	(1.57)	(1.2)	(1.19)
$BO2FS3 * T2$	3.17	0.62	-1.94	0.16	1.74	0.92	-0.46
	(3.94)	(3.63)	(3.57)	(1.53)	(1.8)	(1.36)	(1.12)
$BO3FS3 * T2$	6.44	1.81	-2.98	0.79	4.84*	3.28	-1.14
	(5.78)	(5.71)	(6.35)	(3.45)	(2.72)	(2.05)	(2.07)
$BO2FS45 * T2$	4.51	-4.76	-10.81***	-2.14	4.72*	1.11	-2.73**
	(6.9)	(5.16)	(4.08)	(1.96)	(2.72)	(1.89)	(1.24)
$BO3FS45 * T2$	8.21	-6.86	-20.47*	-5.33	7.37*	1.92	-5.38
	(8.75)	(8.55)	(11.92)	(4.64)	(4.31)	(3.4)	(3.61)
$BO45FS45 * T2$	5.25	-5.99	6.52	-1.89	6.94	2.63	2.33
	(9.48)	(11.65)	(13.03)	(5.49)	(4.6)	(4.48)	(3.81)
$QualT_{t-1}$	0	0.13	-0.09	-0.02	0.01	0.06	-0.03
	(0.12)	(0.12)	(0.11)	(0.04)	(0.05)	(0.04)	(0.04)
R^2	0.0213	0.0766	0.1433	0.0278	0.5775	0.4356	0.4889
N	120	120	120	120	120	120	120
Controls	Child						

C Figures

Figure A1. Histogram of Children's Ages by Birth Order Positions, 2002

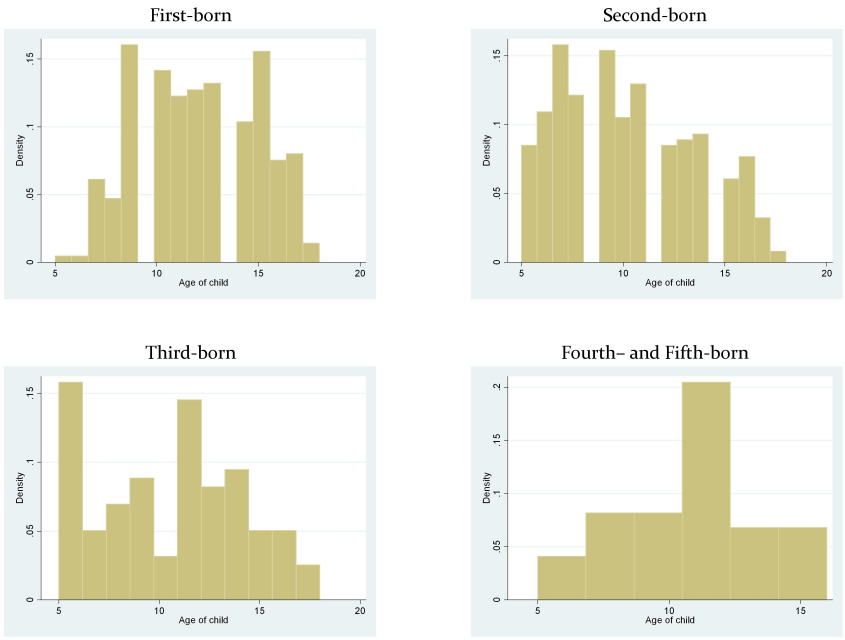


Figure A2. Histogram of Children's Ages by Birth Order Positions, 2007