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The Impact of Household Investments on Early Child Neurodevelopment and on Racial and Socioeconomic Developmental Gaps – Evidence from South America

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I. Introduction

Infant and early child health and development have important effects on future health and human capital accumulation and early child health deficits are carried later on in life (Currie 2009; Currie 2007; Frankel et al. 1996; Gluckman et al. 2008; Murray et al. 2006b; van de Mheen et al. 1998; Victora et al. 2008; Wadsworth and Kuh 1997). For example, higher birth weight has been reported to reduce the risk of coronary heart disease (Frankel et al. 1996) and high blood pressure (Jarvelin et al. 2004) in adulthood while low birth weight has been shown to reduce educational level and wealth (Currie 2009; Victora et al. 2008). Early neurological development and functioning are significant predictors of future health. For example, studies have shown that improved infant development in the areas of motor and language abilities are associated with higher education and improved cognitive and intellectual functioning in adulthood (Murray et al. 2007; Murray et al. 2006a; Taanila et al. 2005).

Early development is a function of both fixed endowments such as genetic factors and variable inputs such as parental and household investments. Child educating activities may play an important role in child development (IOM 2000). For example, Ermisch (2008) shows that household educating activities such as reading to the child have a positive impact on child cognitive development at three years of age. However, estimates of the impacts of parental/household investments on earlier child neurodevelopment are rare.

Family socioeconomic status enhances parental access to the inputs needed in child health production and has positive effects on child health and development, though empirical estimates of the effects vary between studies (Cunha and Heckman 2007; Currie 2009; Doyle et al. 2009; Ghuman et al. 2005; Paxson and Schady 2007). Further, higher family socioeconomic status may compensate for some of the early life deficits in development and weaken their effects on future health. Indeed, studies have shown that delayed child development is more likely to translate into lower adult education in poorer families (Feinstein 2003). The compensatory effects of socioeconomic resources imply that early health deficits will impose a higher burden on future outcomes for children born into poorer families. This interdependency along with the decrease in occurrence of child health problems with improved parental socioeconomic status which in turn enhances future health and human capital attainment may contribute to the multiplicative and consistent intergenerational inheritance of health and socioeconomic endowments (Case et al, 2005; Currie, 2009). Race may also impact parental access to informational and socioeconomic resources to obtain the inputs that are needed for optimal production of child development, and racial gaps in child health are well documented, including in very early health outcomes (Arias et al. 2003; IOM 2009).

Given the importance of early child neurodevelopment as a form of human capital that has life-long and intergenerational implications on health and human capital accumulation, identifying the effects of parental investments on early child neurodevelopment and on socioeconomic and racial gaps in child neurodevelopment becomes essential for developing cost-effective policy interventions to improve development. Such interventions may yield large social and economic returns (Cunha and Heckman 2007). Policy initiatives and interventions to improve early child health and development are more cost-effective than those later in life due to the longer time to reap the benefits and the increasing depreciation of health with age (Grossman 1972). Further, investments at an early age, including during the first two years of life, and the resulting improvement in early development may enhance the returns of investments and developmental growth later in childhood and adolescence due to the complementarity effects between investments and the self-producing effects of developmental skills and abilities over time (Cunha and Heckman 2007).

This paper assesses the effects of parental/household investments on early child neurodevelopment in South America and evaluates the heterogeneity in investment effects by unobserved developmental endowments. Furthermore, the paper evaluates the extent of racial and socioeconomic gaps in early neurodevelopment and the role of parental/household investments in reducing these gaps. In doing so, the paper makes several contributions to studying the production of early child neurodevelopment.

The first contribution is the focus on neurodevelopment very early in life – between 3 and 24 months of age. Most previous economic studies have evaluated the development of children at 3 years of age and older ages. Identifying the effects of investments in the first two years of life is essential for developing interventions that can improve development earlier in life and result in larger returns in later child development and future health and human capital. A second contribution is that the study is among the first to evaluate the heterogeneity in effects of parental/household investments by unobserved developmental endowments. Previous studies have focused on estimating effects at the “mean” of the development outcomes, which may mask important heterogeneities in investment effects. Using quantile regression, this study assesses investment effects at various quantiles of child development. This approach evaluates the heterogeneity in investment effects by the unobserved net endowment levels that determine the child’s ranking on the development distribution.

Another contribution is studying child development in understudied populations with higher rates of poverty and where early health deficits may have larger economic and human capital burden compared to developed countries. Very few economic studies have evaluated the effects of parental/household investments on child development in South America. Identifying ways to improve early child development may bring large health and socioeconomic returns in these populations. Finally, evaluating the extent of socioeconomic and racial gaps in early child development in South America and the role of parental/household investments in these gaps is a novel application, as previous studies are rare. To our knowledge, no previous studies have evaluated the extent of racial gaps in early child neurodevelopment in South America, which has high rates of racial admixture.

The paper proceeds as follows: Section II is a background on early child development and previous studies; Section III describes the data and analytical model; Section IV presents the results, and Section V concludes with a discussion and implications of the study results.

II. Background

Neurodevelopment represents the extent to which the child meets age-expected milestones on neurological and sensory functioning domains including cognitive, gross motor, fine motor, expressive, receptive and social interaction and adaptation functioning (Patel, Pratt, and Greydanus 2002). Early screening of child neurodevelopment is recommended as a standard pediatric care practice (American Academy of Pediatrics 2001).

Child neurodevelopment has important effects on future health and human capital accumulation. Studies have shown that infants who had better neurodevelopment during the first year of life had better educational attainment as adults and higher intelligence scores (Murray et al. 2007; Taanila et al. 2005). Studies have also found earlier achievement of infant gross-motor milestones such as age at standing to be positively related to better cognitive outcomes during adulthood (Murray et al. 2006b).

Child neurodevelopment is a complex process that involves several contributing biologic/genetic, behavioral, social and economic factors (IOM 2000). The effects of several of these factors may begin during pregnancy and extend throughout childhood. Parental/household investments have received considerable attention as potential determinants of child development. A few economic studies have evaluated the effects of these investments on the production of child skills and development and on socioeconomic and racial development gaps. Todd and Wolpin (2007) report a significant effect of maternal ability and home investments including activities such as reading to the child and taking the child to museums on explaining a large portion of the gap in cognitive test scores by race in a sample from the US (Todd and Wolpin 2007).¹ Cunha and Heckman (2008) estimate a dynamic model for production of cognitive and non-cognitive skills and find that skills have self-producing and complementary effects over time, that maternal ability impacts primarily cognitive skills and that parental investments have different effects on cognitive and non-cognitive skills at different ages (larger effects on cognitive skill formation at younger age and larger effects on non-cognitive skill formation at older age) in a sample from the US.²

One limitation of these two seminal studies is that development/skills were evaluated beginning at a relatively late age, 5 years and older, thereby omitting the development process that occurs very early in life. Development and skill production in early life have potential important effects on development and skill production that follows in later

¹Data from the National Longitudinal Survey of Youth (NLSY-79) were used.

²The White male child sample of the NLSY-79 was used.

childhood (Cunha and Heckman 2007). Cunha, Heckman, and Schennach (2010) report another dynamic model of skill-formation that incorporates household investments in the first year of life and psychomotor developmental measures for ages 1–2 years. However, the study focuses on investment effects over time and assumes that the marginal effects of investments made during the first 4 years of life are constant over age until age 6 years (i.e. investment in year of birth has similar effect on development at age 1–2 years as investment during age 1–2 years on development at age 3–4 years). Further, the study does not include psychomotor development measures before the first year of life. Therefore, while providing a seminal model for studying skill formation over time, the study does not provide direct estimates of very early investments on early neurodevelopment.

A few economic studies have evaluated the effects of parental investments at very early ages. Ermisch (2008) finds that parental investments, including reading to the child and taking the child to the library have large positive effects on cognitive performance at 3 years of age, and to a lesser extent, on behavioral performance, and that investment effects partially explain the positive family income effects on child development.³ Paxson and Schady (2007) find that a harsher and less responsive parenting style reduces the child's language development while reading to the child enhances this development with increasing effects by age, in a sample of children between 3 and 6 years of age from Ecuador. The study also finds that investments and parental style explain some but not most of the observed positive effects of socioeconomic status on language development.

Racial and socioeconomic gaps in infant and child health are well documented. For example, the rates of low birth weight, preterm birth and infant mortality are about twice as high among African-American babies compared to White babies in the US (Heron et al. 2010).⁴ Similar gaps have been reported in other populations. For example, in Brazil, the largest country in South America, the rates of infant mortality among Black infants are also twice those of White infants.⁵ However, estimates of the extent of such gaps in early life neurodevelopment in racially admixed populations are less common. In the United States (US), few studies have reported lower early life neurodevelopment among African-American children compared to White children (Ittenbach and Harrison 1990; Vohr et al. 2000).⁶ To our knowledge, there have been no robust studies of the impact of race on early child neurodevelopment in South America. Given the extensive racial admixture in South America and the large socioeconomic and infant health gaps reported by race, evaluating the impact of race on early neurodevelopment in South America is essential for guiding public policies to improve child development. Studies of socioeconomic gaps in early neurodevelopment are also rare worldwide. Ghunam et al. (2005) find insignificant effects

³Ermisch (2008) used a sample from the Millennium Cohort Study in the UK.

⁴The rates of low birth weight (LBW), preterm birth, and infant mortality of African American infants were 13.3%, 17.5% and 14 deaths/1000 births respectively compared to 6.9%, 11% and 5.7 deaths per 1000 births respectively among White infants in 2002 (Arias et al. 2003). The ratios of these rates remained fairly similar in 2005/2007 (Heron et al. 2010). The 2.5 times higher infant mortality among African-American infants has persisted over a long period even when rates of infant mortality were declining for all demographic groups.

⁵The differences in mortality rates by race appear to have increased over the past two decades in certain regions in Brazil. In 1993–1994, infant and under-five mortality rates were 62.3 and 76.1 deaths per 1000, respectively, among Blacks, compared to 37.3 and 45.7 deaths per 1000, respectively, among Whites (Instituto Brasileiro de Geografia e Estatística 1998). In 2002, infant mortality was reported to be about twice as high for Indigenous and Black babies (41.5 and 38.8 deaths per 1000 births, respectively) compared to Whites (21.7 deaths per 1000 births) (Cardoso, Santos, and Coimbra Jr 2005). Also, significantly higher neonatal and infant mortality rates were reported in the City of Pelotas in Southern Brazil in 2004 among babies born to mothers of Black or Mixed race (18.8 and 30.4 deaths per 1000 births, respectively) compared to babies of White mothers (9.6 and 14.9 deaths per 1000 respectively) (Matijasevich et al. 2008). The neonatal and infant mortality rates in this city decreased disproportionately by race between 1982 and 2004 (by 54% and 47%, respectively, among babies of White mothers, compared to 44% and 11%, respectively, among babies of Black/Mixed race mothers). Matijasevich et al. (2008) also reported higher rates of low birth weight and preterm birth (12.3% and 19.8%, respectively) in babies of mothers with Black or Mixed race compared to White mothers (9.6 and 14.4%, respectively).

⁶Vohr et al. (2000) reported a poorer neurodevelopment performance of extremely low birth weight African-American babies (< 1000 gm) around 1.5 years of age compared to Whites.

of family wealth and maternal education on child neurodevelopment except on language in a sample of children at 0–36 months of age from the Philippines. However, the extent to which the results are generalizable is unclear.

There have been very few economic studies of child development in South America (Schady 2006).⁷ Except for Fernald et al (2006), the majority of these studies included older children than the children in our study.⁸ Further, these studies included single-country and fairly small samples, which limit the generalizability of their findings. Our study utilizes a larger sample from five South American countries, which provides an advantage over previous studies in terms of increased generalizability. Another limitation of previous studies in South America is that except for Paxson and Schady (2007), studies have involved fairly simple analytical models that excluded several theoretically relevant inputs and characteristics that may impact child development.

III. Methods

III.A. Child Development Production Function

Child development is a dynamic and complex process that involves interdependencies between inputs at various stages of the child's life and direct effects of earlier development on later development due to the self-producing effects of developmental abilities (Cunha and Heckman 2007; Todd and Wolpin 2003). Unobserved factors such as parental preferences for child's health may result in correlation between parental investments over time. Furthermore, the child's developmental endowments may impact parental investment decisions. Together, these issues pose a huge demand for data in order to estimate dynamic development production models. Instrumental variable and fixed effect models are typically employed to estimate such models (Todd and Wolpin 2007). Other model identification restrictions in datasets with multiple measures of child development and production inputs may be employed (Cunha and Heckman 2007).

Previous studies that pioneered these dynamic models have employed panel data on development and input measures at various ages. Unlike these data sources, the data source that our study employs (described below in detail) includes a one-time assessment of the child's neurodevelopment at ages 3 to 24 months. Therefore, we utilize a cross-sectional model that evaluates the impacts of parental investments on child neurodevelopment where investments and neurodevelopment are measured at the same time.⁹ Given that this study evaluates child development very early in life and that more than half of the sample infants are one year old or younger, the analytical issues of self-producing effects of developmental abilities and correlations and interactions between inputs over time are not applicable for estimating the child development production function in this sample. Also, the potential reverse effects of development on investment are of less concern given the very young age at which investment and development are measured compared to other studies. However, as discussed below, our identification strategy accounts for the endogenous investment selection based on unobserved child health endowments and for potential reverse development effects on investment.

Standard utility maximization and health production theory can be used to specify the child's health/development production (Rosenzweig 1983). Specifically, maternal utility is a function, amongst other things, of child development, which in turn is a function of

⁷Schady (2006) summarized the studies of child development in South America (Schady 2006).

⁸Fernald et al. (2006) found insignificant effects of socioeconomic and household characteristics on mental health development in a sample of children age 13–23 months from low income areas in Mexico. Poor developmental performance increased with child's age (Fernald et al. 2006).

⁹There are no investment measures in the study before the time of neurodevelopment measurement.

investment, other inputs and exogenous factors such as exogenous health endowments (genetic factors). The mother maximizes her utility subject to the production function and the budget constraint, which generates reduced-form functions for investment and inputs as a function of prices, income and the exogenous factors.

A fully specified structural equation of child development production is generally infeasible due to the lack of data on several relevant inputs and exogenous factors. Following the standard approach in the health production literature, we focus on estimating the structural effect of household investments in the form of child educating activities as defined below on development. We employ a development production function that includes investments, other inputs in child development production, and exogenous factors that are theoretically relevant for child development. We specify the child development production function as follows:

$$D_i = \alpha_0 + \lambda I_i + \mathbf{R}_i \delta + \gamma S_i + \mathbf{B}_i \xi + \mathbf{H}_i \omega + e_i, \quad (1)$$

where for child i , D is child neurodevelopment and I includes parental/household investments in D , $\mathbf{R}$ represents child's race, S is maternal socioeconomic status, $\mathbf{B}$ includes maternal health and health behaviors, and $\mathbf{H}$ is a vector of child and household demographic characteristics. Child development production may vary by race and demographic characteristics which may also relate to parental/family preferences towards development (Rosenzweig 1983; Todd and Wolpin 2007). Socioeconomic status enters this model because of potential direct effects on child development. The socioeconomic status measure in this study encompasses both maternal human capital and household wealth as described below in detail. Socioeconomic status as a generalized construct combining these factors may have direct effects on parental self-esteem, stress levels and efficiency in child development production (Currie 2009; Cutler et al 2008). However, wealth also impacts development indirectly through other unobserved inputs. This makes equation (1) a quasi-structural or a hybrid structural function. We describe below in detail how we evaluate the investment effect sensitivity to the model specification including the inclusion of socioeconomic status, other inputs, and demographic variables.

One goal of the study is to evaluate the role of parental investments in contributing to racial and socioeconomic gaps in early child development. Therefore, we also estimate a nested model of equation (1) that excludes investments in order to evaluate changes in the effects of race and socioeconomic status.

III.B. Data and Study Measures

The data sample that we analyze in this paper includes 2,165 infants, 3 to 24 months of age, from five countries in South America.¹⁰ This sample size is within the range of sample sizes employed in previous economic studies of child development (summarized above). The infants were identified and recruited in 2005–2006 by physicians, mostly pediatricians, at 32 pediatric clinics during routine well-child visits in a study of neurodevelopment of children without major health complications in South America. The physicians are affiliated with a longstanding South American epidemiological and Surveillance network involved in infant health outcome studies.¹¹ About 98% of all infants screened were eligible and participated in the study. The study sample included infants who had normal birth outcomes (birth weight and gestational age) and did not have significant early life complications such as

¹⁰The sample was distributed as follows by country: Argentina (671), Bolivia (116), Brazil (525), Chile (388), and Ecuador (465). The “parent” study providing the data for this paper obtained data on neurodevelopment of children without major health problems in South America and was conducted as a supplemental project to a pediatric study within the Global Network for Women’s and Children’s Health Research.

spending more than five days at the hospital after birth or admission to the neonatal intensive care unit. For the purpose of this analysis, the sample is limited to infants whose mothers were one of their primary caregivers (>98% of the main sample) in order to ensure consistent measurement of maternal and household characteristics and reduce measurement error. The study physicians identified the infant sample and obtained the data using the same data collection instruments across all study sites after receiving standard training in study procedures and data instruments. Except for the child neurodevelopment measure which is obtained by the study physicians, the other study measures were reported by the mothers through an in-person interview with the study physicians and staff.

As described below, the sample has significant variation in neurodevelopment, investment, demographic and socioeconomic measures. Most sample characteristics cannot be directly compared to those of the population which are not readily available for the study countries. Nonetheless, the large geographic, demographic and socioeconomic diversity of the sample suggests that it is likely to be representative of a large proportion of the study populations.

III.B.1. Child Neurodevelopment—We measure neurodevelopment by the child's performance on the Bayley Infant Neurodevelopmental Screener (BINS) (Aylward 1995), which is a screening instrument that identifies infants at risk of neurological impairment.¹² The study pediatricians evaluated neurodevelopment of each study child using the BINS.¹³ The BINS assesses the following four areas of ability in young children 3 to 24 months of age: basic neurological functions/intactness (posture, muscle tone, movement, asymmetries, abnormal indicators), expressive functions (gross motor, fine motor, oral motor/verbal), receptive functions (visual, auditory, verbal), and cognitive processes (object permanence, goal-directedness, problem solving). The BINS includes 11–13 items (depending on the child's age) that are each scored as optimal or nonoptimal and summed. The total score may be classified into a two (high or low) or three- (low, moderate, or high) category risk rating for neurodevelopmental problems based on the test norms (Aylward 1995; Aylward and Verhulst 2000).

The BINS has been shown to be strongly predictive of scores on diagnostic neurodevelopment instruments including the McCarthy Scales of Children's Abilities and the Bayley-II and has good psychometric properties (Aylward 1995; Aylward and Verhulst 2000).¹⁴ The instrument has been employed in developmental follow-up clinics (Aylward and Verhulst 2000; Leonard, Piecuch, and Cooper 2001; Macias et al. 1998) and in screening of general pediatric populations (Blackman 1999; Dobrez et al. 2001).

In this study, we use the total BINS score to generate a measure of the child's neurodevelopment rate conditional on the child's age and use that as the primary measure of the child's neurodevelopment. The development rate represents the percentage deviation of each child's BINS score from the sample mean of BINS scores at the child's age, where age is in months. By construction, the development rate is centered at 0 and ranges from -82.1 to 47.761, with increasing values indicating enhanced development compared to other children in the sample of the same age. The neurodevelopment rate measure has several advantages

¹¹The physicians who participated in the study were affiliated with the Latin American Collaborative Study of Congenital Anomalies (ECLAMC), which is a large network of hospitals and physicians in South America who are involved in epidemiological surveillance of birth defects and infant health outcome studies (Castilla and Orioli 2004; Wehby et al. 2006; Wehby, Castilla, and Lopez-Camelo 2010; Wehby et al. 2009a; Wehby et al. 2009b, 2009c, 2009d; Wehby et al. 2011).

¹²Derived from the Bayley Infant Neurodevelopment Screener. Copyright © 2004. Harcourt Assessment Inc. Used with Permission. All rights Reserved.

¹³The study pediatricians received the same training in the use of the BINS prior to the initiation of data collection.

¹⁴The BINS has an internal consistency ranging from 0.73 to 0.85, a test-retest reliability of 0.71 to 0.84, and an inter-rater reliability of 0.79 to 0.96 (Aylward 1995).

compared to the categorical risk measure based on the BINS norms. First, the rate measure does not impose neurodevelopmental norms that may not be applicable to the South American sample.¹⁵ Second, the measure has an intuitive and direct interpretation as the child neurodevelopment relative to other children of the same age. Third, this measure is continuous and allows applying quantile regression to evaluate the heterogeneity in parental/household investment effects by unobserved endowments that affect child neurodevelopment.¹⁶ However, in order to evaluate the sensitivity of the results to this measure, child's development is alternatively measured by the child's status of being at high versus low risk for neurodevelopmental problems based on the BINS norms and the two-category risk classification of the BINS (Aylward and Verhulst 2000).

III.B.2. Parental/Household Investments—Parental/household investments in child development are measured by an index of the intensity/frequency of engaging the child in activities that may impact the child's neurodevelopment by stimulating the child's cognitive and motor skills. These activities include reading to the child, the child playing with puzzles, blocks and board games and the child playing with drawing/art material, all measured on an ordinal scale of activity participation¹⁷. For example, reading to infants and children is expected to have positive effects on child language development through stimulating the child's receptive and expressive functions (High et al. 2000; Westerlund and Lagerberg 2008), and has been found to be significantly related to the child's cognitive development in several studies (Ermisch 2008a; Paxson and Schady 2007). Previous economic studies of child development have included conceptually similar investment measures (Cunha and Heckman 2007; Ermisch 2008; Paxson and Schady 2007; Todd and Wolpin 2007). These investments were considered culturally appropriate in South America and are common in the study sample.¹⁸

The investment index is constructed using principal component analysis (PCA) under the assumption that parental preferences for and efficiency in investing in child's development explain the majority of variation in the intensity of participation in the above-mentioned activities. The scoring coefficients of the first principal component are used as weights for activity participation and intensity.¹⁹ PCA is used to generate the weights due to its theoretical advantage over approaches that arbitrarily assign weights (such as assigning equal weights to the various investment activities). The PCA weights are estimated using the method of Kolenihov and Angeles (2004) which estimates by maximum likelihood polychoric correlations between latent variables based on the ordinal activity measures (Kolenikov and Angeles 2004). The index is centered at 0 and ranges from -1.151 to 2.731, with increasing values indicating greater investment.

III.B.3. Race/Ethnic ancestry—Race/ethnicity measurement in South America is complex due to the multiple and admixed ancestries including primarily Native, European and African ancestries. The study measures "race" by the child's ancestries as reported by

¹⁵The current available norms are based on samples of infants from the US.

¹⁶We do not use the raw total BINS score as a direct development measure for two reasons: 1- The limited total score distribution (ranging from 0–13); 2- the difference in the number of BINS items, by design, and the resulting "artificial" difference in raw total scores by age.

¹⁷Participation is measured on a scale of 0, 1–2, 3–4 and 5 or more times per week.

¹⁸About 62.1%, 20.5%, 9.7% and 7.7% of the study mothers reported reading to the child 0, 1–2, 3–5 and 5 or more times per week, respectively. About 61%, 11.3%, 10.7%, and 17% reported engaging the child in playing with puzzles, blocks and board games 0, 1–2, 3–5 and 5 or more times per week, respectively. About 53.1%, 16.4%, 11% and 19.5% reported engaging the child in playing with art material 0, 1–2, 3–5 and 5 or more times per week, respectively.

¹⁹The first principal component, which captures most of the variation between the activities included in the index, explains 68.8% of the variation in the investment activities. Table A1 in the Appendix lists the scoring coefficients of the activities included in the investment index.

the mother.²⁰ The study model includes mutually exclusive indicators of African and Native ancestries, compared to other ancestries.²¹

III.B.4. Socioeconomic Status—Socioeconomic status (SES) is measured by an index that includes both wealth and human capital characteristics. The wealth characteristics include the following asset ownership and household quality indicators: ownership of radio, TV, fridge and car; employing a worker in the household; working on family's agricultural land; source of drinking water; type of toilet/sewage facility; principal house flooring type; principal wall material; principal roofing material; and number of household members per sleeping room. The human capital indicators include maternal education and employment/occupational activity, both measured on ordinal scales.

The socioeconomic status index is generated using PCA (Kolenikov and Angeles 2004).²² Similar to the investment index, we choose PCA to generate the weights for the socioeconomic index variables due to its theoretical advantage over approaches that arbitrarily assign weights (such as assigning equal weights to owning a TV versus a Fridge). The assumption made when using PCA to generate this index is that long-run socioeconomic status explains the maximum variance in the used asset ownership and household quality indicators and human capital characteristics (Filmer and Pritchett 2001). Long-run socioeconomic status is the relevant measure of socioeconomic endowments when studying child development especially in less developed countries given the stability and consistent intergenerational inheritance of these endowments. Under this assumption, we use the scoring coefficients of the first principal component as weights for the included variables to construct an index of socioeconomic status.²³ The index is centered at 0 and ranges from -5.327 to 2.996, with increasing values indicating higher socioeconomic status.

III.B.5. Other study measures—Vector **B** in equation (1) includes two indicators for maternal mental health problems (depression and other mental health problems) and chronic physical illness that requires regular treatments and/or medicine, based on maternal self-report. Maternal health may have direct effects on fetal health through biological pathways and on child neurological development through maternal efficiency and ability to care for the child. **B** also includes maternal smoking during the prenatal period (at and during pregnancy) due to its potential adverse effects on fetal and child neurodevelopment (Faden and Graubard 2000; Herrmann, King, and Weitzman 2008).²⁴ Also included is an indicator for whether the child has private insurance as a medical care input for child development through influencing the child's access to healthcare.²⁵

²⁰Eight ancestry categories were used in the main study.

²¹In order to define mutually exclusive groups of race/ethnicity, the child's race/ethnicity is defined as African when African ancestry is reported, regardless of whether other ancestries are reported. The child's race/ethnicity is defined as Native when Native ancestry is reported without African ancestry, regardless of whether other ancestries are reported. The reference group for ethnic ancestry includes children who are not reported to have African or Native ancestry, the majority of whom are of European ancestry. This classification follows other infant health studies using similarly measured ancestry information (Lopez Camelo et al. 2006).

²²Previous studies have found PCA wealth indices of similar asset ownership and household quality indicators to be reliable measures of long term economic status (Filmer and Pritchett 2001). Income and expenditures are hard to measure in less developed countries and may not be good measures of long-term wealth primarily due to interruptions of income flow with changes in employment status, high unemployment or self-employment rates and the variations in short term expenditures (Filmer and Pritchett 2001). The PCA generated wealth indices based on the asset indicators have been shown to be well predictive of child schooling enrollments (Filmer and Pritchett 2001), prenatal care demand (Jewell 2007) and child development (Paxson and Schady 2007) in less developed countries.

²³The scoring coefficients represent "weights" of the importance of the various asset ownership, household quality and human capital indicators in explaining the variance of the socioeconomic status index. The first principal component explains about 33.6% of the variation. The detailed scoring coefficients are available from the authors upon request.

²⁴Smoking may adversely impact fetal health through hypoxia and other pathways (Walsh 1994). There is no data in this study on maternal smoking at the same time as child development.

Vector $\mathbf{H}$ includes relevant maternal and child demographics and household characteristics that may impact maternal preferences for child development. These include maternal age (and age-squared) and marital status, child's age (in months) and gender, number of child's older siblings, an indicator for a sibling with developmental, learning, mental or physical disability or chronic health problem and number of household members.²⁶ Table 1 lists the distribution of the study variables.

III.C. Estimation of the Child Development Production Function

III.C.1. Investment effect heterogeneity—The effects of parental/household investments on child development are likely to be heterogeneous by unobserved child endowments or abilities. These endowments include unobserved genetic, environmental, social and parental human capital factors that may modify the effects of investments and other observed inputs on child development. If these heterogeneities exist, then estimating equation (1) by mean-effect models alone such as OLS that estimate investment effects at the mean of the child neurodevelopment rate (D) distribution will not be very informative.

Quantile regression (QR) provides a flexible and powerful approach to evaluate investment effect heterogeneity by unobserved developmental endowments. QR estimates investment effects at various locations of the distribution of D and evaluates effect heterogeneity by unobserved endowments that determine the child's rank on this distribution. The model follows Chernozhukov and Hansen (2004, 2005 and 2006):

$$D=Q(I, \mathbf{R}, S, \mathbf{B}, \mathbf{H}, U), \text{ where } U \sim (0, 1). \quad (2)$$

U is a uniformly distributed “unobserved” endowment or ability level that, conditional on the observed variables, determines the child's location on the distribution of D . For quantile q ($0 < q < 1$), $Q(I, \mathbf{R}, S, \mathbf{B}, \mathbf{H}, q)$ is the conditional q th quantile of D . QR estimates the effects of investments and other observed inputs on Q holding U constant at q , and evaluates effect heterogeneity by q (or U):

$$D=Q(\alpha_{0q}+\lambda_q I+\mathbf{R}\delta_q+\gamma_q S+\mathbf{B}\xi_q+\mathbf{H}\omega_q). \quad (3)$$

If investments are exogenous, then standard QR (Koenker and Bassett 1978; Koenker and Hallock 2001) may be used to estimate equation (3) by minimizing the sum of weighted absolute deviations between conditioned and actual D for a specific q :

²⁵The study countries have private insurance programs some of which are demanded to supplement public insurance and to access services not covered in public clinics and hospitals. Private insurance through employment or individual purchase is common in the study countries (Belmartino 2000; Lobato 2000).

²⁶Child development rate and child's age in months have zero bivariate correlation by construction. Age is highly correlated with the investment index ($r=0.54$). Given that development risks may change by age due in part to inputs included in the model that may vary by age, we add child's age in months to the model. Further, as we discuss below, we estimate the child development production function by quantile regression, and add age to the model in order to account for differences in the distribution of the child development rate by age. Child's gender is included given that it might be correlated with parental preferences for investment in child development and given potential differences in development by gender. Having more siblings is expected to reduce the amount of maternal time and economic resources available to investment in each child's development, which might negatively impact development. On the other hand, having older siblings might increase the child's playing and learning activities, which might have positive effects on development. Having a disabled sibling may have negative effects on child development through reducing the amount of maternal time available for investment in child's health. However, parents may determine their investments based in part on the child's health endowments and may compensate or substitute for health endowments (Becker 1991; Becker and Tomes 1976). Further, the sibling disability indicator may also partially reflect some family-level endowments for child development that are not included in equation (1) such as genetic endowments and parental preferences for investments in child development.

$$\min[q \sum_{D_i \geq Q_i}^n |D_i - Q_i| + (1-q) \sum_{D_i < Q_i}^n |D_i - Q_i|], \quad (4)$$

where n is the number of observations. However, parental/household investments (I) in child development may be endogenous to child development. That is, parents may choose investment type and intensity based on child's endowments and abilities, and may compensate for low endowments or complement high endowments, depending on investment costs and expected returns (Becker 1991; Cunha and Heckman 2007). If investments are strong substitutes for innate abilities in child development production, parents may invest more in children with lower innate abilities/endowments. In contrast, if innate abilities and investments are complements, parents may invest more in children with higher innate abilities/endowments. Therefore, the type and magnitude of bias due to not observing innate abilities/endowments (such as genetic abilities) in equation (4) may vary by the quantile (q) of the distribution of child development (D).

Investments are also a function of parental preferences for child health and development, and may be correlated with unmeasured inputs that affect child development. For example, unobserved nutritional investments likely have direct effects on child neurodevelopment (Paxson and Schady 2007) and may be correlated with investments I . Correlated unobserved inputs may result in an omitted variable bias in equation (4) (Chernozhukov and Hansen 2005).

In order to account for the potential endogenous selection of I , the study employs the instrumental variable quantile regression (IVQR) model (Chernozhukov and Hansen 2004, 2005, 2006). The instruments should predict I but should be unrelated to U and unobserved variables that result in bias and should have no direct effects on D . The model applies a grid search over the parameter space (λ) for I in order to identify the value of λ that minimizes the absolute value of coefficient (β) in the following equation:

$$D - \lambda I = Q(\mathbf{X}\boldsymbol{\kappa}_q(\lambda) + Z\beta_q(\lambda)), \quad (5)$$

where Z is the least squares projection of I on the identifying instruments and $\mathbf{X}$ ($\mathbf{X}$ includes all the other production function inputs and $\boldsymbol{\kappa}$ is a vector of their coefficients).²⁷ The IVQR estimate of λ at q is the value that results in β being as close as possible to 0. Note that both β and $\boldsymbol{\kappa}$ are a function of λ .

The IVQR model is estimated for quantiles 0.1, 0.25, 0.5, 0.75 and 0.9 of the child neurodevelopment rate (D). The child development function is also estimated by standard QR (equation 4) as a reference model with standard error estimates based on 2000 bootstrap replications. The study also estimates the investment effects on the mean of D using OLS and 2SLS with Huber-type robust standard errors that account for sample clustering across the study clinics (Wooldridge 2002).

All models include country fixed effects in order to account for any differences between the sample countries in measured and unmeasured relevant inputs and in development, which may lead to biased estimates of investment effects. This approach essentially uses within country variation in estimating the effects of investments and other model inputs on D . It is possible that the investment and other variable effects may vary by country and that it is restrictive to pool the study countries together into one model. However, our goal is to

²⁷The conditional moments for identification and details on the estimation can be found in Chernozhukov and Hansen (2005, 2005, 2006).

estimate the average investment effect across the study sample, which is expected to be representative of large percentages of the study country populations.

III.C.2. Instruments—The study uses two different types of instruments for parental/household investments in child development (I) and compares the estimated investment effects between them in order to gauge the sensitivity of the investment effect estimates to the employed instruments. The premise is that given that these two instruments exploit theoretically different sources of variation in investments, it is expected that they would result in fairly similar estimates if they are unrelated to the potential relevant unobservables described above.

The first instrument is the average area-level investment in child development at the site/clinic where the child was enrolled into the study. For each child, this area-level instrument is the average investment for the *other* children at the same study site as the child, *excluding* the child's own investment level. The theory is that the instrument will generate within-country geographic variation in investment that is due to *area-level* differences in characteristics that affect investment such as availability of parent education programs about child development and local pediatricians' practices in advising parents about investments in child development. It is very unlikely that area-level differences based on *other* children's investment levels are correlated with the child's own innate abilities and health endowments that may impact parental investment levels.

It is theoretically possible that parents may sort themselves into areas that provide better investment opportunities if they have high preferences for investment, such as better schools. If so, it is possible that area-level investment rates for other children in the same area as the child are correlated with the investment preferences of the child's parents, and therefore, with other unobserved investments. However, this is unlikely to be the case in this sample for several reasons. First, the area is not defined based on a specific residential neighborhood, but based on the study clinic that the child attended for routine well-child care, which likely attracts several residential neighborhoods with different socioeconomic backgrounds and investment preferences. Therefore, the study site represents a broader area than a residential neighborhood and likely reflects rather a source of variation in investment that is determined outside the household. One empirical support for this result is that the within study site variation in investment and socioeconomic status significantly exceeds the between site variation. Specifically, 17% of the investment variance is between the study sites, compared to 83% that is within the study sites. Also, 27% of the socioeconomic status variance is due to between study site variation, compared to 73% that is due to within study site variation. This highly suggests that there is substantial within study area variation in investment preferences and very limited area-level sorting based on investment preferences. Furthermore, the very young age of the children in this sample, which is lower than average school age by at least 3–4 years, suggests that parents may be less likely to sort themselves into areas based on the areas' schooling opportunities compared to an older sample. It is important to note that the study child was the only child for about half of the sample (48.4%). These factors support the exogeneity of the area-level instrument. We employ another instrument specification using this area-level instrument that adds an interaction term with socioeconomic status, given that parents with greater socioeconomic resources and higher human capital are more efficient in identifying and making use of available community resources to increase their investment in child development.

The second instrument is the availability of other family caregivers to the child besides the mother (who was a caregiver for all the sample children as an inclusion criterion into the sample). Family caregivers are expected to impact investment levels and, therefore, satisfy the first instrument condition in several ways. First, the availability of family caregivers may

reduce parental costs of investment in child development as these caregivers can directly contribute to the investment activities (such as grandparents reading to the child or engaging the child in playing with drawing/art material or puzzle games). The study assesses the effects of “household” investments including but not limited to parental investments – investments provided by other family caregivers are included in the total investment. Therefore, family caregiver availability does not violate the instrument condition of having no direct effect on the outcome but indirect effects through the endogenous treatment. Family caregivers can also provide standard childcare and allow parents to dedicate more of their household time to investing in child development (such as reading to the child or engaging the child in other educational activities included in the investment index) instead of standard childcare. Both of these functions fit the first instrument condition.

One might argue that this instrument may impact development through other ways, such as allowing parents to dedicate more time to work and income earning, which may impact child development through unobserved pathways, such as improving the child’s nutrition. While this is theoretically possible, the model accounts for maternal employment/occupational status and long-run household wealth, which should account for such potential indirect effects on development. It is also theoretically possible that family caregiver availability is related to the child’s health and development level in the overall population. For instance, it may be argued that grandparents may dedicate more time to care for children who lag in development and need further investment. The opposite may also occur, with grandparents caring more for more endowed children. However, one strong safeguard against such bias in our analysis is that the parent study that provides the data for our study only enrolled children without significant health complications, chronic illnesses or developmental disabilities²⁸. Only children with normal birth outcomes (apgar scores ≥ 6 ; birth weight ≥ 2500 grams; gestational age ≥ 37 weeks) and without major early life complications such as requiring oxygen after birth, admission to the neonatal intensive care unit, major surgeries, illnesses requiring regular treatment for more than two weeks (excluding surgeries and ear infections), documented developmental delay and disabilities were enrolled. Therefore, while the sample has sufficient variation in the neurodevelopment measure, the sample does not include chronically ill and disabled children or those with significant health complications that may be related to family caregiver availability.

The family caregiver availability instruments that we use are two indicators for whether grandparents and other relatives (other than father or siblings) are considered by the mother to be primary caregivers for the child.²⁹ These two instruments are significant predictors of investment in the study sample and pass the over-identification restrictions. Other caregivers including the father, siblings or other caregivers do not have significant effects on investment in this sample. Note that the model includes the numbers of siblings and household members as covariates, and that caregivers are not limited to individuals who live in the household with the child.

As described below, the area-level employed instruments have large F-statistics – 112–230 in the full specification (accounting for clustering across the study sites) – that are well above the typically accepted thresholds for non-weak instruments.³⁰ The caregiver availability instruments have an F-statistic of 7.3 (accounting for sample clustering). Given that the caregiver instruments may be considered within the range for weak instruments and that the usual asymptotic standard error estimates might not approximate well the finite

²⁸The parent study screened every potential subject to ensure that children met the eligibility criteria of no major health complications, chronic health problems or developmental disabilities.

²⁹The child may have multiple primary caregivers – these indicators are not mutually exclusive.

³⁰Instruments with an F-statistic of less than 10 are typically considered weak instruments in linear models (Staiger and Stock 1997).

sample estimates, confidence bounds for the IVQR investment effects that are robust for weak instruments are estimated for these instruments (Chernozhukov, Hansen, and Jansson 2007).³¹ Confidence bounds that are robust for weak instruments and sample clustering are also estimated for the 2SLS investment effects with these instruments using the conditional likelihood ratio (CLR) statistic, which is more powerful than other statistics under weak-instruments (Andrews, Moreira, and Stock 2006).

III.C.3. Binary Developmental Risk Status Specification—An additional specification with the child's developmental risk status (based on the BINS norms) as the dependent variable is used in order to evaluate the sensitivity of the results to the development measure. The model is estimated with probit regression for exogenous investments and IV probit when treating investments as endogenous. The IV probit involves simultaneous estimation of the developmental risk and the investment functions by conditional maximum likelihood (Wooldridge 2002). The over-identification restrictions in this specification are tested using the two-stage IV probit model (Baum 1999; Lee 1992; Newey 1987).

III.C.4. Investment Effect Sensitivity to Model Specification—Other inputs in equation (1) besides investments may also be endogenous to child development. For example, maternal health and health behaviors in vector **B** and having a sibling with developmental disabilities and chronic health problems are also a function of unobserved health and social endowments and maternal preferences for health that may also affect *D*. We do not have access to instruments in order to directly account for the potential endogenous selection of all these factors. A common approach in the health production literature is to evaluate the structural parameter estimate sensitivity (i.e. the investment effect sensitivity) to the exclusion of such endogenous variables (e.g. Corman, Joyce, and Grossman 1987). Therefore, we evaluate the potential effects of these variables on the household investment effects by estimating a specification that excludes maternal smoking, maternal health problems, child private insurance status, and having a sibling with developmental disabilities or chronic health problems and comparing to the investment effects in the full specification.

We also evaluate the investment effect sensitivity to including socioeconomic status and demographic characteristics by estimating an additional specification that only includes investments and child's ancestry, age and gender.

IV. Results

IV.A. Investment Effects on the Mean of the Child Development Rate

Panel A in Table 2 reports the OLS and 2SLS investment effects from equation (1) on the mean of the child neurodevelopment rate as defined in section III.B.1.³² Under OLS, investment has a significant positive effect on child development – a one standard deviation increase in investment increases the development rate by about 4.2 percentage-points (about one-quarter of a standard deviation).³³

The 2SLS investment effect is significant using either instrument specification and more than twice as large as the OLS estimate – a one standard deviation increase in investment

³¹The robust confidence bounds may not necessarily be wider than the standard asymptotic bounds (Chernozhukov and Hansen 2008).

³²Table A2 in the Appendix reports the full OLS and 2SLS regression results. Table A3 reports the first stage coefficients of 2SLS models.

³³The 4.2 percentage-point effect is obtained from multiplying the coefficient of the investment index by the standard deviation of this index (3.65×1.15).

increases the development rate by about 10.5–13.7 percentage-points, with the larger effect estimated using the area-level instruments. The 2SLS effect when using the family caregiver availability instruments is significant using the 95% confidence bounds that are robust for weak instruments. The area-instrument and its interaction with socioeconomic status pass the over-identification test at $p=0.79$, and the family caregiver availability instruments pass this test at $p=0.56$. The instruments have significant effects on investment (F-statistic of 230 for the area-level instrument alone and 111.9 when interacted with socioeconomic status; F-statistic of 7.3 for the family caregiver availability instrument). The model rejects exogenous investment ($p < 0.05$) when using the area-level instrument but not with the family caregiver instrument ($p=0.2$).

IV.B. Investment Effects on the Quantiles of Child Neurodevelopment Rate

IV.B.1. QR Estimates—Panel B in Table 2 reports the investment effects on the 0.1, 0.25, 0.5, 0.75 and 0.9 quantiles of the child neurodevelopment rate.³⁴ Investment has positive effects on the child development rate that are larger at lower quantiles (effects are different at the five quantiles at $p < 0.05$). An investment increase of one standard deviation increases development by 4.9 and 2.1 percentage-points at the 0.1 and 0.9, quantiles, respectively.

IV.B.2. IVQR Estimates—Panel B in Table 2 reports the IVQR investment effects of equation (1).³⁵ The IVQR effects are larger than the QR estimates that ignore endogenous investment selection by about 2–4 times, and are generally comparable across the three instrument groups. The effects at lower quantiles (0.1 and 0.25) are significant and larger than those at higher quantiles under the three instrument groups. A one standard deviation increase in investment increases the development rate by about 16.1–16.4 and 15–15.6 percentage-points at the 0.1 and 0.25 quantiles, respectively, which are larger than the QR estimates by about 3 times – the lower IVQR effects are observed when using the caregiver availability instruments. The IVQR effect at the 0.25 quantile is significant at $p < 0.05$ using the weak-instrument confidence bounds for the family caregiver instruments (the IVQR effect at the 0.1 quantile is significant at $p < 0.1$ using the weak-instrument robust confidence bounds).

The investment effects are also significant at the median and higher quantiles when using the area-level instrument (alone or interacted with socioeconomic status) and decrease consistently with the quantile order. However, the investment effects are marginally significant at the median and the 0.75 quantile and insignificant at the 0.9 quantile when using the family caregiver instruments. An increase in investment by one standard deviation increases development by 8–13.4 percentage-points at the median (the larger effects are when using the area-level instrument), 8.1–8.4 percentage-points at the 0.75 quantile and 5–5.2 percentage-points at the 0.9 quantile (based on using the area-level instrument).

IV.C. Investment Effects on the Child Development Risk Status

Panel C in Table 2 reports the marginal effects of parental/household investment on the BINS binary risk status, as estimated by probit and IV probit regression.³⁶ These effects represent changes in the child's probability of being at high risk of neurodevelopmental problems. In the probit model, a one-point investment increase reduces significantly this probability by 0.07. The investment effect in the IV probit model is larger (in absolute

³⁴Table A4 in the Appendix reports the full QR coefficients.

³⁵Tables A5 and A6 in the Appendix report the full IVQR results using the area-level instrument and the family caregiver instruments, respectively. The results using the area-level instrument with an interaction term with socioeconomic status are virtually identical to those of the area-level instrument alone and are available from the authors upon request.

³⁶Table A7 reports the full probit and IV probit results for the development risk function.

value) than the probit estimate and comparable across the three instrument groups. A one-point investment increase reduces the probability of being considered at high risk for neurodevelopmental problems by 0.28. The exogenous selection of investment is rejected in this model under the three instrument groups (at $p < 0.0001$ for the area-level instrument groups and 0.1 for the family caregiver availability instruments).

IV.D. Investment Effect under Alternative Model Specifications

The main patterns of results described above are generally insensitive to model specification. The IV investment effects are comparable between the full specification and the nested specification that excludes potentially endogenous inputs.³⁷ The IVQR investment effects decrease slightly under the specification that additionally excludes socioeconomic status and maternal and household demographic characteristic, except for the investment effect at the 0.1 quantile using the family caregiver instruments, which increases. The IV probit investment effects on high risk status decrease slightly in this specification (by about 11%). However, the same general pattern of IV effects is observed under all specifications. Also, the over-identification and exogeneity test results are consistent with the full specification.

IV.E. Racial and Socioeconomic Gaps and the Role of Investments

Table 3 reports the effects of race and socioeconomic status on the mean and quantiles of child development rate in specifications that exclude and include parental/household investments in both the standard and IV models.³⁸ The IV model results are reported when using area-level investment rate as an instrument or family caregiver availability as instruments.³⁹ The results are generally comparable between the instrument groups.

Significant differences are observed in early child neurodevelopment by race/ethnic ancestry. Excluding investments, children of African and Native ancestry have lower development rates at the mean by about 6 and 4.3 percentage-points, respectively, than children of other ancestries. The gaps in development by race are larger at the lower quantiles of the development rate, though differences between quantiles are only significant for Native ancestry. Moderate socioeconomic gaps in development are also observed, with children in households of higher socioeconomic status having higher developmental rates, mainly at the mean and lower quantiles. An increase of one standard deviation in the socioeconomic status index increases child development rate by about 1.2 percentage-points at the mean and by about 1.4 percentage-points at the 0.25 quantile.

About one third of the developmental gap at the mean between children of African ancestry and children of other ancestries are explained by parental investments when treated as endogenous. When treated as exogenous, investments explain only one tenth of the developmental gap between children of African ancestry and children of other ancestries at the mean. Also, investments explain more than one third of the developmental gap at the 0.1 quantile when treated as exogenous, but explain much less at the higher quantiles – the gap increases at the 0.9 quantile when adding investments into the model. However, when treated as endogenous, investments explain almost entirely the developmental gap at the 0.1 quantile and most of the gap at the 0.25 quantile, both of which become insignificant, but

³⁷Table A8 reports the investment effects when excluding the potentially endogenous inputs including maternal health, siblings' disability indicator, smoking and child's private insurance status. Table A9 reports these effects when excluding the endogenous inputs, socioeconomic status and maternal and household demographic characteristics and retaining only the child's ancestry, age and gender and the country fixed effects. The full regression results for these specifications are available from the authors upon request.

³⁸Table A11 reports the full OLS and QR results when excluding investments from the model.

³⁹The results for the effects of ancestry and socioeconomic status are virtually the same in the specifications that use the area-level investment rate and an interaction with socioeconomic status as instruments and are available from the author upon request.

only explain a small portion of the gap at higher quantiles (about one quarter and one fifth of the gaps at the median and 0.75 quantile, respectively).

In contrast, investments do not generally explain the developmental gaps observed between children of Native ancestry and those of other ancestries. These gaps change minimally and even increase at higher quantiles of the development rate distribution after including investments and accounting for their endogenous selection. When treated as endogenous, investments explain about one tenth and up to one half of the gaps at the 0.1 and 0.25 quantiles, respectively, but increase the gaps at the higher quantiles.

Investments explain entirely the observed socioeconomic gaps in the development rate. When accounting for the endogenous selection of investments, the coefficients of socioeconomic status switch to negative, and are significant at quantile 0.5 and marginally significant at quantile 0.25 and at the mean when using the area-level instrument. This suggests that socioeconomic status has no positive effect in this sample on development beyond its effects on investments.⁴⁰

IV.F. Effects of Other Factors on Development

We briefly discuss the main effects of other model variables on the child neurodevelopment rate (Table A2). Children of single mothers had significantly lower development rates by about 3.6 percentage-points at the mean compared to married mothers. Furthermore, children who have a disabled sibling have lower development rates by about 4 percentage-points and those who have older siblings have lower development rates by about 1 percentage-point per sibling. Finally, children from Bolivia and Chile had lower development rates compared to those from Argentina by about 17 and 7 percentage-points at the mean, respectively. These results highlight the importance of parental/household investment effects for child development which exceed most of these other effects.

V. Discussion and Conclusions

This study is one of the first to evaluate investment effects in child development at a very early age and to assess the effect heterogeneity by developmental endowments. We find that early parental/household investment in child development defined as engaging the child in educating activities between 3 and 24 months of age, has large returns in child neurodevelopment in this period. This indicates that the first two years of life are a highly sensitive period for parental investment. Further, children who have a lower net level of developmental endowments (social, economic, and biologic endowments that improve development) and who are at the left margin of the development distribution, will benefit more from these investments, compared to children with more endowments. This suggests that these investments may substitute for other endowments in the production of child neurodevelopment in the first two years of life. In other words, these investments will improve more the neurodevelopment of children who are at high developmental risks than children who are at low developmental risks. This also suggests that parents may to a large extent compensate their children through these investments for exogenously low development endowments.

The study finds significant racial and socioeconomic gaps in child neurodevelopment in the study sample. Parental/household investments explain some of the racial gaps and the entire

⁴⁰The correlation coefficient between the socioeconomic status and the investment index is 0.24. However, this does not explain this result. The variance inflation factor for the socioeconomic status coefficient is 1.6 in the regression that includes investments, which is significantly below the threshold that suggests collinearity problems. Investments explain the entire positive effects of maternal education on development, when substituting education for the socioeconomic status index. Results are available from the authors upon request.

socioeconomic gap, suggesting that policy programs that increase such investments may have large returns in reducing the socioeconomic and some of the racial gaps in early child development in South America. Investments are lower for infants of African ancestry and infants in poorer households (see Table A4).⁴¹ Nonetheless, the study finds racial gaps in development that are not explained by investments and the study variables, primarily between infants of Native ancestry and those of other (non-African) ancestries. Other factors that may result in these gaps may include differences in access to area-level inputs that impact neurodevelopment such as healthcare availability and quality as well as other household inputs, such as nutritional status (Paxson and Schady 2007), which was not available in the study data. Residential racial segregation may result in differences in access to area-level resources (Acevedo-Garcia et al. 2008) and has been documented in certain South American countries such as Brazil (Telles 2004), though data are limited for the other countries.⁴² Further studies are needed to identify the determinants of racial gaps in early child development in South America in order to design cost-effective policies to reduce these gaps.

The study results suggest that the effects of parental investment on early child development may be underestimated if the endogenous selection of these investments is ignored. This may be due to parents choosing to invest more in children at higher risks for neurodevelopmental problems. The underestimation of the investment returns may be large for children with low developmental endowments (the ratio of the IVQR to QR estimates at the lower quantiles is about 3). The identification of the investment effects is challenging due to the role of unobserved preferences and inputs that may confound this estimation when ignored. Furthermore, instruments are more challenging to find in this area. This study utilizes IV models to account for such unobserved factors and alternative instrument groups in order to gauge the investment effect sensitivity to the instruments. The instruments perform adequately using standard tests and the results are generally insensitive to the specific instruments. Further, unobserved inputs such as nutritional investments are unlikely to be related to the employed instruments.⁴³ The study also finds the investment effects to be generally insensitive to the model specification assumptions. Observing similar effects under multiple instrument groups and model specifications support the robustness of the estimated investment effects. However, as in all instrumental variable applications, the results are qualified by the instruments. Therefore, replicating the study in the future with other instruments is important. Nonetheless, the study adds significantly to the literature on the role of household investment in child development.

In conclusion, the study finds large positive returns of parent/household investments through child educating activities on early child neurodevelopment. Differences in investments explain the whole socioeconomic gap and part of the racial gaps in development. Given that investment returns are larger among children with lower developmental endowments, establishing policies to enhance parental investments may lead to significant reductions in

⁴¹Ignoring the endogenous selection of investments may result in overestimation of the development gaps between infants of African ancestry and other ancestries and of socioeconomic developmental gaps, suggesting that variations in relevant unobserved factors may contribute to some of the observed differences by race and socioeconomic status in models that assume exogenous selection of investments. This may have contributed to the results in previous studies that found significant effects of socioeconomic status on development after including household investments without accounting for their endogenous selection.

⁴²Frequent and chronic maternal exposure to stress due to racial discrimination may also be an unmeasured factor that may contribute to the racial/ethnic gaps in child health (Lu and Halfon 2003), and previous studies have shown differences in chronic stress measures by race in other populations (Geronimus et al. 2006). However, the model includes indicators for maternal mental (including depression) and chronic physical health problems.

⁴³Non-family childcare arrangements (including formal daycare) may impact investment levels and child neurodevelopment. However, such childcare arrangements (reported in 1.8% of the sample) have no effects on investments. Furthermore, adding non-family childcare arrangements into the model does not change the investment effects. Detailed results are available from the authors upon request.

socioeconomic gaps in early child development in South America. These policies may involve increasing the counseling of pregnant women and mothers of young children at prenatal and pediatric care clinics of the importance of early investments for child development. There is limited information on the current counseling practices in South America, though significant practice variations are expected. Policies that reduce investment costs for families of low socioeconomic status by subsidizing the cost of reading material, puzzles, drawing material, and other investment inputs may have high development returns. Given the fairly low cost of these interventions and the large expected future returns, including higher population wealth and education and lower crime rates (Heckman, Stixrud, and Urzua 2006), these policies are likely to be cost-effective and to result in large social returns. Policies that increase parental time allocation towards investments and reduce time costs of investments may also be considered, though studies of specific policies are needed in order to evaluate the net policy effects. Further work is needed to identify the effects of these early investments on later childhood development and their interactions with later investments. Finally, future work is needed to evaluate the effects of additional types of parent/household investments on early child neurodevelopment.

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Appendix

Table A1

Principal component analysis scoring coefficients of the parent investment index

Reading to the child	
0 times per week	−0.323
1–2 times per week	0.318
3–4 times per week	0.611
5 or more times per week	0.989
Playing with puzzles, blocks and board games	
0 times per week	−0.377
1–2 times per week	0.258
3–4 times per week	0.457
5 or more times per week	0.891
Playing with drawing/art material	
0 times per week	−0.451
1–2 times per week	0.174
3–4 times per week	0.409
5 or more times per week	0.851

Table A2

OLS and 2SLS coefficients of the child development rate function^a

	OLS	2SLS		
		Area instrument	Area instrument with SES interaction	Caregiver availability instruments
Parental/household investment	3.65 *** (0.60)	11.89 *** (3.63)	11.84 *** (3.55)	9.10 ** (4.21)
African ancestry	-5.27 *** (1.27)	-3.72 ** (1.70)	-3.73 ** (1.71)	-4.25 ** (1.76)
Native ancestry	-4.20 ** (1.68)	-3.91 ** (1.77)	-3.91 ** (1.77)	-4.01 ** (1.71)
Socioeconomic status	0.30 (0.33)	-1.17 * (0.63)	-1.16 * (0.62)	-0.67 (0.75)
Maternal mental health problems	-1.81 (1.26)	-1.28 (1.41)	-1.28 (1.41)	-1.46 (1.35)
Maternal chronic physical health problems	-1.68 (1.40)	-2.47 (1.65)	-2.46 (1.65)	-2.20 (1.62)
Maternal smoking during prenatal period	-1.58 * (0.88)	-1.93 ** (0.93)	-1.93 ** (0.93)	-1.81 ** (0.85)
Child has private insurance	-1.57 (1.64)	-1.82 (1.53)	-1.82 (1.53)	-1.74 (1.57)
Maternal age	-0.62 ** (0.29)	-0.92 *** (0.34)	-0.92 *** (0.34)	-0.82 ** (0.36)
Maternal age squared	0.01 ** (0.00)	0.02 *** (0.01)	0.02 *** (0.01)	0.01 ** (0.01)
Mother is single	-3.56 *** (1.08)	-3.60 *** (0.96)	-3.60 *** (0.96)	-3.59 *** (0.96)
Mother is in a stable relationship	-1.39 (0.82)	-0.75 (0.93)	-0.76 (0.93)	-0.97 (0.82)
Child's age in months	-0.33 *** (0.09)	-1.10 *** (0.34)	-1.09 *** (0.34)	-0.84 ** (0.41)
Male child	-2.44 *** (0.56)	-1.93 *** (0.60)	-1.94 *** (0.60)	-2.11 *** (0.63)
Number of child's siblings	-1.07 *** (0.36)	-0.88 ** (0.38)	-0.89 ** (0.38)	-0.95 *** (0.36)
Disabled sibling	-5.03 ** (2.41)	-4.40 ** (1.90)	-4.40 ** (1.90)	-4.61 ** (1.97)
Number of other household members	0.45 ** (0.21)	0.38 * (0.21)	0.38 * (0.21)	0.40 * (0.21)
Brazil	-2.40 (2.42)	1.67 (3.67)	1.65 (3.65)	0.29 (3.74)
Bolivia	-15.30 (9.93)	-17.64 ** (7.18)	-17.63 ** (7.22)	-16.85 ** (8.03)
Chile	-5.81 * (3.19)	-6.91 *** (2.18)	-6.91 *** (2.18)	-6.54 *** (2.36)
Ecuador	-5.94 ** (2.50)	-2.76 (3.58)	-2.78 (3.54)	-3.84 (3.37)
Constant	20.08 *** (5.08)	31.83 *** (6.23)	31.76 *** (6.22)	27.85 *** (8.37)

*, ** and *** indicate p < 0.1, < 0.05 and < 0.01, respectively.

Standard errors are in parentheses.

^aDerived from the Bayley Infant Neurodevelopment Screener. Copyright © 2004. Harcourt Assessment Inc. Used with Permission. All rights Reserved.

Table A3

First stage coefficients of the 2SLS model for the child development rate

	Area instrument	Area instrument with SES interaction	Caregiver availability instruments
Area-level investment	0.717 *** (0.047)	0.708 *** (0.048)	
Area-level investment × socioeconomic status		0.059 * (0.032)	

	Area instrument	Area instrument with SES interaction	Caregiver availability instruments
Primary caregivers-Grandparents			0.100 (0.076)
Primary caregivers-Other relatives			0.413 *** (0.112)
African ancestry	-0.191 ** (0.072)	-0.203 *** (0.068)	-0.185 * (0.095)
Native ancestry	-0.050 (0.053)	-0.049 (0.053)	-0.035 (0.091)
Socioeconomic status	0.133 *** (0.019)	0.136 *** (0.018)	0.170 *** (0.021)
Maternal mental health problems	-0.110 * (0.063)	-0.105 (0.063)	-0.070 (0.081)
Maternal chronic physical health problems	0.092 (0.085)	0.091 (0.086)	0.094 (0.098)
Maternal smoking during prenatal period	0.011 (0.063)	0.008 (0.063)	0.031 (0.068)
Child has private insurance	0.026 (0.063)	0.019 (0.062)	0.034 (0.076)
Maternal age	0.036 * (0.020)	0.036 * (0.020)	0.031 (0.019)
Maternal age squared	-0.001 (0.0003)	-0.001 (0.0003)	-0.0004 (0.0003)
Mother is single	0.004 (0.059)	0.008 (0.059)	-0.037 (0.077)
Mother is in a stable relationship	-0.036 (0.046)	-0.039 (0.045)	-0.081 * (0.045)
Child's age in months	0.094 *** (0.006)	0.094 *** (0.006)	0.093 *** (0.006)
Male child	-0.067 * (0.036)	-0.067 * (0.036)	-0.060 (0.037)
Number of child's siblings	-0.011 (0.022)	-0.011 (0.022)	-0.013 (0.022)
Disabled sibling	-0.038 (0.130)	-0.037 (0.131)	-0.070 (0.145)
Number of other household members	0.007 (0.010)	0.006 (0.009)	0.002 (0.010)
Brazil	-0.086 (0.064)	-0.090 (0.060)	-0.485 *** (0.123)
Bolivia	0.041 (0.097)	0.022 (0.088)	0.299 (0.346)
Chile	0.002 (0.064)	-0.008 (0.062)	0.097 (0.228)
Ecuador	-0.089 (0.059)	-0.108 * (0.058)	-0.410 *** (0.107)
Constant	-1.531 *** (0.288)	-1.511 *** (0.290)	-1.350 *** (0.274)

*, ** and *** indicate $p < 0.1$, < 0.05 and < 0.01 , respectively.

Standard errors are in parentheses.

Table A4

Ordinary quantile regression coefficients of the child development rate function^a

	Quantile				
	0.1	0.25	0.5	0.75	0.9
Parental/household investment	4.90 *** ^b (0.80)	4.06 *** ^b (0.58)	3.10 *** ^b (0.36)	2.36 *** ^b (0.39)	2.08 *** ^b (0.61)
African ancestry	-5.42 * (3.04)	-5.45 *** (1.96)	-4.24 *** (1.28)	-5.03 ** (2.00)	-3.66 ** (1.81)
Native ancestry	-4.58 ** (1.83)	-4.29 *** (1.18)	-3.41 *** (0.75)	-3.12 *** (0.79)	-1.84 *** (0.70)
Socioeconomic status	0.42 (0.78)	0.37 (0.54)	0.40 (0.35)	0.22 (0.36)	0.33 (0.30)
Maternal mental health problems	-3.38 (2.83)	-1.95 (1.93)	-1.61 (1.66)	-0.46 (1.54)	-2.58 (1.69)
Maternal chronic physical health problems	-2.95 (3.74)	-1.34 (2.81)	-0.94 (1.16)	-0.85 (2.11)	0.059 (1.41)
Maternal smoking during prenatal period	-0.45 (2.50)	-0.39 (1.46)	-2.37 ** (1.02)	-0.70 (1.38)	-0.0058 (1.20)

	Quantile				
	0.1	0.25	0.5	0.75	0.9
Child has private insurance	-1.50 (2.07)	-2.08 (1.44)	-2.61 *** (0.90)	-1.16 (1.01)	-1.13 (0.97)
Maternal age	-1.11 (0.97)	-0.93 * (0.52)	-0.26 (0.37)	-0.47 (0.44)	-0.14 (0.39)
Maternal age squared	0.021 (0.016)	0.016 * (0.0087)	0.0042 (0.0065)	0.0084 (0.0075)	0.0020 (0.0068)
Mother is single	-5.49 ** (2.52)	-4.35 *** (1.42)	-3.73 *** (1.00)	-2.95 ** (1.18)	-0.59 (1.18)
Mother is in a stable relationship	-3.32 * ^a (1.91)	-0.91 ^a (1.15)	-1.76 * ^a (0.88)	-0.28 ^a (0.98)	0.53 ^a (0.81)
Child's age in months	-0.71 *** ^c (0.14)	-0.44 *** ^c (0.11)	-0.19 *** ^c (0.064)	-0.017 ^c (0.063)	0.060 ^c (0.074)
Male child	-4.19 *** ^b (1.45)	-3.24 *** (0.99)	-1.64 ** (0.64)	-1.38 ** (0.70)	-0.91 ^b (0.71)
Number of child's siblings	-1.15 ^b (0.77)	-1.16 ** ^b (0.46)	-1.32 *** ^b (0.32)	-0.85 *** ^b (0.38)	0.027 ^b (0.38)
Disabled sibling	-8.20 * (4.72)	-6.95 (4.44)	-4.94 ** (2.49)	-2.94 (2.35)	-5.01 ** (2.01)
Number of other household members	0.47 (0.33)	0.40 ** (0.20)	0.46 ** (0.19)	0.19 (0.23)	0.14 (0.15)
Brazil	-3.20 ^c (2.31)	-3.64 *** ^c (1.56)	-4.76 *** ^c (0.95)	-2.54 ^c (1.67)	0.23 ^c (1.10)
Bolivia	-21.9 *** ^c (6.46)	-18.3 *** ^c (3.96)	-14.3 *** ^c (1.84)	-9.20 *** ^c (2.33)	-5.97 *** ^c (2.06)
Chile	-7.39 *** ^c (2.10)	-8.17 *** ^c (1.55)	-7.02 *** ^c (1.02)	-5.02 *** ^c (1.00)	-2.27 *** ^c (1.15)
Ecuador	-6.33 *** ^c (2.25)	-7.01 *** ^c (1.34)	-7.86 *** ^c (0.98)	-7.36 *** ^c (1.10)	-2.71 *** ^c (1.11)
Constant	15.3 (15.3)	20.0 ** (7.81)	16.9 *** (5.26)	23.0 *** (6.50)	20.2 *** (5.78)

*, ** and *** indicate p <0.1, <0.05 and <0.01, respectively.

Standard errors are in parentheses.

^b and ^c indicate that the quantile effects are significantly different at p<0.05 and p<0.01, respectively.

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Table A5

IVQR coefficients of the child development rate function using the area instrument^a

	Quantile				
	0.1	0.25	0.5	0.75	0.9
Parental/household investment	14.23 *** (1.99)	13.47 *** (1.87)	11.69 *** (1.94)	7.19 *** (2.23)	4.54 ** (2.28)
African ancestry	-1.0 (3.75)	-3.22 (2.11)	-3.62 ** (1.74)	-4.9 *** (1.75)	-3.31 * (1.92)
Native ancestry	-4.93 *** (1.72)	-3.22 *** (1.21)	-3.86 *** (0.92)	-3.42 *** (0.77)	-2.24 *** (0.87)
Socioeconomic status	-0.88 (0.8)	-1.1 * (0.62)	-1.58 *** (0.6)	-0.37 (0.46)	-0.14 (0.47)
Maternal mental health problems	-5.72 * (3.01)	0.09 (2.49)	0.48 (1.62)	-0.67 (1.53)	-2.47 * (1.38)
Maternal chronic physical health problems	-0.07 (2.51)	-2.96 (2.22)	-1.83 (2.04)	-1.18 (2.01)	-0.67 (1.71)
Maternal smoking during prenatal period	-2.33 (2.79)	-1.36 (1.56)	-2.79 ** (1.38)	-0.53 (1.39)	-1.33 (1.3)
Child has private insurance	-1.34 (1.91)	-2.44 (1.53)	-2.76 ** (1.12)	-2.35 ** (1.02)	-1.09 (1.01)
maternal age	-0.99 (0.94)	-1.91 *** (0.6)	-0.49 (0.46)	-0.59 (0.48)	-0.09 (0.41)
maternal age squared	0.02 (0.02)	0.03 *** (0.01)	0.01 (0.01)	0.01 (0.01)	0.002 (0.01)
Mother is single	-3.48 * (2.07)	-2.11 (1.73)	-2.98 ** (1.37)	-2.56 ** (1.15)	-1.17 (1.2)
Mother is in a stable relationship	-2.14 (1.93)	-0.1 (1.3)	-0.69 (1.08)	-0.4 (0.93)	1.32 (0.99)
Child's age in months	-1.62 *** (0.22)	-1.48 *** (0.21)	-1.1 *** (0.21)	-0.5 *** (0.21)	-0.18 (0.21)

	<i>Quantile</i>				
	0.1	0.25	0.5	0.75	0.9
Male child	-4.34 *** (1.41)	-1.3 (1.03)	-2.01 ** (0.83)	-1.21 * (0.72)	-1.08 (0.75)
Number of child's siblings	-0.75 (0.79)	-0.68 (0.5)	-1.16 *** (0.39)	-0.35 (0.45)	-0.16 (0.46)
Disabled sibling	-0.56 (4.48)	-3.65 (3.05)	-5.22 ** (2.28)	-5.97 *** (2.29)	-3.71 (2.27)
Number of other household members	0.26 (0.34)	0.39 * (0.22)	0.24 (0.22)	0.28 (0.22)	0.17 (0.21)
Brazil	0.99 (3.35)	1.3 (1.95)	-0.93 (1.67)	0.82 (1.71)	1.5 (1.71)
Bolivia	-15.32 *** (4.33)	-16.6 *** (2.28)	-20.79 *** (2.35)	-12.19 *** (3.14)	-8.92 *** (2.94)
Chile	-8.22 *** (2.04)	-9.41 *** (1.7)	-7.89 *** (1.25)	-5.5 *** (1.27)	-4.06 *** (1.5)
Ecuador	-0.51 (2.84)	-3.75 ** (1.71)	-5.49 *** (1.43)	-4.36 *** (1.33)	-3.19 *** (1.19)
Constant	19.53 (14.0)	40.28 *** (9.42)	28.77 *** (7.3)	30.59 *** (6.99)	22.72 *** (6.98)

*, ** and *** indicate $p < 0.1$, < 0.05 and < 0.01 , respectively.

Standard errors are in parentheses.

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Table A6

IVQR coefficients of the child development rate function using caregiver instruments^a

	<i>Quantile</i>				
	0.1	0.25	0.5	0.75	0.9
Parental/household investment	14.1 ** (5.65)	13.08 *** (3.26)	6.94 * (4.07)	7.01 * (4.01)	9.2 (5.87)
African ancestry	-1.02 (4.85)	-2.96 (2.13)	-3.74 ** (1.53)	-4.70 ** (1.86)	-3.25 (2.24)
Native ancestry	-4.50 ** (1.78)	-2.76 ** (1.21)	-3.96 *** (0.84)	-3.47 *** (0.78)	-3.10 *** (0.97)
Socioeconomic status	-0.75 (1.16)	-1.15 (0.77)	-0.42 (0.82)	-0.32 (0.67)	-0.80 (0.87)
Maternal mental health problems	-5.27 (3.65)	-0.12 (2.59)	-0.26 (1.97)	-0.58 (1.53)	-2.32 (1.7)
Maternal chronic physical health problems	-0.62 (3.04)	-2.97 (2.22)	-1.02 (1.50)	-1.04 (2.03)	-2.23 (1.98)
Maternal smoking during prenatal period	-2.34 (2.74)	-1.21 (1.59)	-2.98 ** (1.33)	-0.36 (1.52)	-1.97 (1.48)
Child has private insurance	-1.55 (1.96)	-2.17 (1.53)	-2.52 ** (1.07)	-2.46 ** (1.07)	-0.70 (1.30)
maternal age	-0.92 (0.95)	-1.78 *** (0.67)	-0.36 (0.46)	-0.74 (0.49)	-0.29 (0.62)
maternal age squared	0.02 (0.02)	0.03 *** (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Mother is single	-3.39 (2.12)	-2.48 (1.82)	-3.19 *** (1.18)	-2.54 ** (1.24)	-2.28 * (1.38)
Mother is in a stable relationship	-1.99 (2.74)	-0.09 (1.31)	-1.21 (0.99)	-0.38 (0.93)	1.24 (1.29)
Child's age in months	-1.67 *** (0.55)	-1.44 *** (0.35)	-0.61 (0.44)	-0.49 (0.37)	-0.57 (0.48)
Male child	-4.45 *** (1.45)	-1.53 (1.05)	-1.98 *** (0.72)	-1.16 (0.72)	-0.80 (0.98)
Number of child's siblings	-0.50 (0.71)	-0.65 (0.52)	-1.12 *** (0.32)	-0.33 (0.48)	-0.40 (0.54)
Disabled sibling	-0.51 (6.93)	-4.12 (3.24)	-6.72 *** (2.18)	-6.11 ** (2.52)	-5.90 * (3.49)
Number of other household members	0.17 (0.37)	0.40 * (0.22)	0.40 * (0.21)	0.26 (0.22)	0.25 (0.26)
Brazil	1.14 (4.98)	1.51 (2.34)	-3.31 (2.02)	0.50 (2.16)	3.84 (3.06)
Bolivia	-15.54 *** (5.36)	-16.79 *** (2.57)	-17.18 *** (3.30)	-11.95 *** (4.07)	-12.84 ** (5.53)
Chile	-8.11 *** (2.08)	-8.83 *** (1.82)	-7.26 *** (1.43)	-5.54 *** (1.52)	-5.33 *** (2.42)

	<i>Quantile</i>				
	0.1	0.25	0.5	0.75	0.9
Ecuador	-0.65 (4.93)	-3.69* (1.91)	-7.23*** (1.62)	-4.52** (1.82)	-2.75* (1.58)
Constant	18.69 (14.29)	37.36*** (11.41)	23.0** (9.83)	32.51*** (7.68)	31.42** (14.87)

*, ** and *** indicate p <0.1, <0.05 and <0.01, respectively.

Standard errors are in parentheses.

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Table A7

Probit and IV probit regression coefficients of the child development risk status function^a

	Probit	IV Probit		
		Area instrument	Area instrument with SES interaction	Caregiver availability instruments
Parental/household investment	-0.273*** (0.062)	-0.910*** (0.114)	-0.910*** (0.109)	-0.910*** (0.240)
African ancestry	0.519*** (0.105)	0.264** (0.120)	0.262** (0.120)	0.286 (0.184)
Native ancestry	0.303** (0.137)	0.201 (0.123)	0.200 (0.122)	0.217 (0.142)
Socioeconomic status	-0.035 (0.032)	0.097*** (0.038)	0.095*** (0.036)	0.095 (0.069)
Maternal mental health problems	-0.008 (0.133)	-0.051 (0.134)	-0.050 (0.133)	-0.051 (0.134)
Maternal chronic physical health problems	0.112 (0.130)	0.162 (0.132)	0.163 (0.132)	0.152 (0.132)
Maternal smoking during prenatal period	0.133 (0.095)	0.134 (0.084)	0.134 (0.084)	0.131 (0.084)
Child has private insurance	0.039 (0.145)	0.049 (0.102)	0.049 (0.102)	0.050 (0.106)
maternal age	0.072** (0.034)	0.085*** (0.032)	0.084*** (0.032)	0.082*** (0.031)
maternal age squared	-0.001** (0.001)	-0.001*** (0.001)	-0.001*** (0.001)	-0.001*** (0.001)
Mother is single	0.309*** (0.089)	0.241*** (0.073)	0.242*** (0.072)	0.248*** (0.076)
Mother is in a stable relationship	0.131* (0.073)	0.050 (0.074)	0.050 (0.074)	0.053 (0.071)
Child's age in months	0.002 (0.008)	0.067*** (0.014)	0.067*** (0.014)	0.066** (0.028)
Male child	0.154*** (0.060)	0.079 (0.059)	0.080 (0.059)	0.082 (0.065)
Number of child's siblings	0.066* (0.035)	0.035 (0.034)	0.035 (0.034)	0.039 (0.038)
Disabled sibling	0.370* (0.214)	0.235 (0.147)	0.235 (0.146)	0.244 (0.166)
Number of other household members	-0.031* (0.016)	-0.019 (0.015)	-0.019 (0.015)	-0.020 (0.016)
Brazil	0.062 (0.243)	-0.293 (0.228)	-0.291 (0.228)	-0.292 (0.300)
Bolivia	0.988 (0.625)	0.934*** (0.318)	0.931*** (0.316)	0.990*** (0.326)
Chile	0.508 (0.312)	0.448** (0.183)	0.447** (0.183)	0.494** (0.208)
Ecuador	0.517** (0.214)	0.123 (0.221)	0.123 (0.218)	0.144 (0.307)
Constant	-2.490*** (0.547)	-2.988*** (0.507)	-2.981*** (0.509)	-2.970*** (0.503)
Chi-square [df] of instrument effects on investments		232.29*** [1]	235.58*** [2]	13.78*** [2]

*, ** and *** indicate p <0.1, <0.05 and <0.01, respectively.

Standard errors are in parentheses.

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Table A8

Effects of parent/household investments on child development rate – first nested specification^a

Mean effects on development rate				
OLS		3.65*** (0.6)		
		Area instrument	Area instrument with SES interaction	Caregiver availability instruments
2SLS		11.77*** (3.75)	11.69*** (3.69)	8.95** (4.40) [1.42,21.72]
F Statistic		236.58***	113.86***	7.31***
Over- identification Chi-square (1) [p value]		-	0.14 [p=0.71]	0.25 [p = 0.62]
Exogenous investment F(1,31)		4.88**	4.92**	1.47
Quantile effects on development rate				
		Area instrument	Area instrument with SES interaction	Caregiver availability instruments
Quantile	QR		IVQR	
0.1	5.10*** (0.84)	15.34*** (1.99)	14.39*** (1.8)	13.87*** (4.85) [−5.93,33.66]
0.25	4.11*** (0.55)	14.6*** (2.06)	14.3*** (2.02)	13.5*** (3.05) [5.62,23.36]
0.5	2.98*** (0.37)	11.36*** (1.91)	11.38*** (1.91)	4.86 (3.06) [−2.06,42.94]
0.75	2.39*** (0.39)	6.91*** (2.17)	6.79*** (2.03)	6.4 (4.2) [−4.36,27.93]
0.9	1.86*** (0.59)	5.51** (2.16)	5.38** (2.15)	8.41 (5.53) [−6.49,55.23]
Marginal effects on development risk status				
Probit		−0.072*** (0.018)		
		Area instrument	Area instrument with SES interaction	Caregiver availability instruments
IV Probit		−0.28*** (0.053)	−0.279*** (0.051)	−0.278*** (0.111)
Exogenous investment Chi-square (1)		17.84***	19.5***	2.89*
Over-identification Chi-square (1) [p value]			0.006 [0.938]	1.57 [0.21]

*, **, and *** indicate p <0.1, <0.05 and <0.01, respectively.

Standard errors are in parentheses. 95% confidence bounds for 2SLS and IVQR that are robust for weak instruments are included in brackets. This child development specification excludes the following potential endogenous inputs: maternal health, prenatal smoking, child insurance, and sibling disability status.

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Table A9

Effects of parent/household investments on child development rate – second nested specification^a

Mean effects on development rate				
OLS		3.83*** (0.68)		
		Area instrument	Area instrument with SES interaction	Caregiver availability instruments
2SLS		10.46*** (3.43)	10.47*** (3.4)	8.68** (3.87) [1.94,17.73]
F Statistic		529.33***	277.97***	8.68***
Over-identification Chi-square (1) [p value]		-	0.05 [p=0.83]	0.14 [p = 0.71]
Exogenous investment F(1,31)		4.56**	4.62**	1.69
Quantile effects on development rate				
		Area instrument	Area instrument with SES interaction	Caregiver availability instruments
Quantile	QR		IVQR	
0.1	4.82*** (0.88)	13.64*** (1.49)	13.63*** (1.47)	17.0*** (3.51) [0.94,43.39]
0.25	4.06*** (0.56)	13.09*** (1.43)	12.93*** (1.43)	10.39*** (2.85) [5.38,18.1]
0.5	3.24*** (0.37)	9.44*** (1.42)	8.65*** (1.4)	5.12* (2.67) [0.19,21.42]
0.75	2.46*** (0.35)	5.11*** (1.76)	4.51*** (1.6)	4.24 (3.36) [-1.4,21.5]
0.9	1.69*** (0.551)	4.08** (1.92)	4.07** (1.89)	6.73 (6.86) [-42.35,43.76]
Marginal effects on development risk status				
Probit		-0.078*** (0.02)		
		Area instrument	Area instrument with SES interaction	Caregiver availability instruments
IV Probit		-0.251*** (.052)	-0.252*** (.051)	-0.243*** (0.09)
Exogenous investment Chi-square (1)		15.95***	16.61***	3.11*
Over-identification Chi-square (1) [p value]			0.136 [0.712]	1.078 [0.299]

*, **, and *** indicate p < 0.1, < 0.05 and < 0.01, respectively.

Standard errors are in parentheses. 95% confidence bounds for 2SLS and IVQR that are robust for weak instruments are included in brackets. This child development specification includes only child's ancestry, age and gender and country fixed effects in addition to investments.

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Table A10Regression coefficients of the child development rate function excluding investments^a

	OLS	QR - Quantile				
		0.1	0.25	0.5	0.75	0.9
African ancestry	-5.96 *** (1.27)	-8.72 *** (3.28)	-6.12 *** (1.89)	-5.18 *** (1.27)	-5.68 *** (2.03)	-3.47 ** (1.75)
Native ancestry	-4.33 ** (1.75)	-5.06 *** ^b (1.68)	-5.28 *** ^b (1.20)	-3.48 *** ^b (0.75)	-2.81 *** ^b (0.90)	-1.34 *** ^b (0.66)
Socioeconomic status	0.96 ** (0.38)	1.01 (0.70)	1.11 ** (0.51)	0.73 ** (0.34)	0.62 * (0.36)	0.44 (0.28)
Maternal mental health problems	-2.05 (1.29)	-0.26 (3.14)	-2.17 (1.64)	-1.56 (1.62)	-0.99 (1.40)	-2.77 * (1.64)
Maternal chronic physical health problems	-1.33 (1.41)	-2.93 (3.97)	-1.41 (2.73)	-1.58 (1.58)	-1.25 (1.74)	0.022 (1.28)
Maternal smoking during prenatal period	-1.43 (0.96)	-0.25 (2.70)	-0.92 (1.52)	-2.18 * (1.13)	-0.054 (1.47)	1.01 (1.14)
Child has private insurance	-1.46 (1.74)	-2.32 (2.18)	-1.96 (1.52)	-1.97 * (1.04)	-0.86 (1.02)	-0.16 (0.85)
maternal age	-0.49 (0.30)	-0.66 (0.90)	-0.62 (0.56)	-0.38 (0.44)	-0.26 (0.44)	-0.12 (0.38)
maternal age squared	0.01 * (0.00)	0.013 (0.015)	0.011 (0.0095)	0.0068 (0.0075)	0.0049 (0.0074)	0.0021 (0.0064)
Mother is single	-3.55 *** (1.22)	-4.38 * ^b (2.39)	-3.75 ** ^b (1.67)	-4.04 *** ^b (1.04)	-2.18 * ^b (1.21)	-0.27 ^b (1.04)
Mother is in a stable relationship	-1.67 * (0.83)	-2.49 ^b (1.99)	-1.44 ^b (1.14)	-2.09 ** ^b (0.85)	-0.10 ^b (0.93)	0.76 ^b (0.71)
Child's age in months	0.01 (0.07)	-0.40 *** ^c (0.12)	-0.060 ^c (0.080)	0.099 * ^c (0.056)	0.22 *** ^c (0.051)	0.23 *** ^c (0.043)
Male child	-2.66 *** (0.58)	-4.17 *** (1.52)	-3.00 *** (1.03)	-1.89 *** (0.67)	-1.29 * (0.72)	-0.92 (0.62)
Number of child's siblings	-1.15 *** (0.38)	-1.32 * (0.72)	-1.08 ** (0.49)	-1.28 *** (0.30)	-0.84 ** (0.41)	-0.31 (0.33)
Disabled sibling	-5.31 * (2.76)	-8.83 (5.71)	-8.48 ** (4.21)	-4.24 (2.88)	-4.13 * (2.40)	-6.48 ** (3.26)
Number of other household members	0.48 ** (0.23)	0.41 (0.33)	0.34 * (0.20)	0.41 ** (0.20)	0.30 (0.22)	0.095 (0.15)
Brazil	-4.20 * (2.36)	-4.98 ** ^c (2.39)	-6.72 *** ^c (1.49)	-5.49 *** ^c (1.05)	-3.41 * ^c (1.81)	-0.31 ^c (1.03)
Bolivia	-14.27 (11.08)	-26.9 *** ^c (6.48)	-17.2 *** ^c (4.40)	-11.7 *** ^c (2.21)	-8.17 *** ^c (1.96)	-2.52 ^c (2.14)
Chile	-5.32 (3.81)	-8.58 *** ^c (2.25)	-8.23 *** ^c (1.56)	-5.19 *** ^c (1.15)	-5.51 *** ^c (1.24)	-0.27 ^c (0.96)
Ecuador	-7.34 *** (2.41)	-8.26 *** ^c (2.11)	-9.09 *** ^c (1.42)	-9.17 *** ^c (1.00)	-8.11 *** ^c (1.01)	-1.63 ^c (1.03)
Constant	14.88 *** (5.08)	6.69 (14.6)	13.0 (8.14)	15.3 ** (6.16)	16.9 *** (6.41)	17.0 *** (5.70)

*, ** and *** indicate p < 0.1, < 0.05 and < 0.01, respectively.

Standard errors are in parentheses.

^b and ^c indicate that the differences in effects between quantiles are significant at p < 0.05 and p < 0.01, respectively.

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Table 1

Descriptive statistics of study variables

Variable	Mean	Standard Deviation
Child development rate ^a	0.00	15.10
Child developmental risk status (high versus low) ^a	0.20	0.40
Parental/household investment	0.00	1.15
African ancestry	0.11	0.32
Native ancestry	0.42	0.49
Socioeconomic status	0.00	1.27
Maternal mental health problems	0.07	0.26
Maternal chronic physical health problems	0.05	0.22
Maternal smoking during prenatal period	0.10	0.30
Child has private insurance	0.21	0.41
Maternal age	27.17	6.54
Maternal age squared	780.87	376.79
Mother is single	0.15	0.36
Mother is in a stable relationship	0.35	0.48
Child's age in months	11.68	6.69
Male child	0.50	0.50
Number of child's siblings	0.95	1.31
Disabled sibling	0.03	0.16
Number of other household members	4.31	2.09
Grandparents are primary caregivers	0.13	0.33
Other relatives (non-siblings) are primary caregivers	0.04	0.20
Brazil	0.24	0.43
Bolivia	0.05	0.23
Chile	0.18	0.38
Ecuador	0.21	0.41

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Table 2

Effects of parent/household investments on child development – full specification^a

Panel A. OLS and 2SLS regression effects on development rate mean			
OLS	3.65*** (0.6)		
	Area instrument	Area instrument with SES interaction	Caregiver availability instruments
2SLS	11.89*** (3.63)	11.84*** (3.55)	9.10** (4.21) [1.64, 21.18]
F statistic	230.0***	111.87***	7.31***
Over-identification chi-square (1) [p value]	-	0.068 [p=0.79]	0.34 [p=0.56]
Exogenous investment F (1,31)	5.33**	5.43**	1.68

Panel B. QR and IVQR effects on development rate quantiles				
	Area instrument	Area instrument with SES interaction	Caregiver availability instruments	
Quantile	QR	QR	IVQR	
0.1	4.90*** (0.80)	14.23*** (1.99)	14.04*** (1.91)	14.1** (5.65) [-5.93,33.66]
0.25	4.06*** (0.58)	13.47*** (1.87)	13.59*** (1.83)	13.08*** (3.26) [5.62,23.36]
0.5	3.10*** (0.36)	11.69*** (1.94)	11.07*** (1.91)	6.94* (4.07) [-2.06,42.94]
0.75	2.36*** (0.39)	7.19*** (2.23)	7.3*** (2.12)	7.01* (4.01) [-4.36,27.93]
0.9	2.08*** (0.61)	4.54** (2.28)	4.39* (2.26)	9.2 (5.87) [-6.49,55.23]

Panel C. Marginal effects on development risk status			
Probit	-0.072*** (0.018)		
	Area instrument	Area instrument with SES interaction	Caregiver availability instruments
IV Probit	-0.28*** (0.051)	-0.28*** (0.049)	-0.277*** (0.109)
Exogenous investment chi-square (1)	19.19***	21.12***	3.03*
Over-identification chi-square (1) [p value]		0.000 [0.991]	1.52 [0.22]

*, ** and *** indicate p <0.1, <0.05 and <0.01, respectively.

Standard errors are in parentheses. 95% confidence bounds for 2SLS and IVQR that are robust for weak instruments are included in brackets. Area instrument includes average investment at the child's community level, calculated for each child, excluding the child's own investment level. Area instrument with socioeconomic status (SES) interaction includes the average investment at the child's community level (same as area instrument), as well as an interaction term with the SES index. Note that socioeconomic status index is included as a covariate in the model (both in the investment and child development functions).

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Table 3

Race and socioeconomic status (SES) Effects on child development rate^a

Effect	Excluding Investment	Including Investment (exogenous)	Including Investment (area instrument)	Including Investment (caregiver instruments)
African ancestry				
Mean	-5.96*** (1.27)	-5.27*** (1.27)	-3.73** (1.75)	-4.25** (1.79)
q=0.1	-8.72*** (3.28)	-5.42* (3.04)	-1.0 (3.75)	-1.02 (4.85)
q=0.25	-6.12*** (1.89)	-5.45*** (1.96)	-3.22 (2.11)	-2.96 (2.13)
q=0.5	-5.18*** (1.27)	-4.24*** (1.28)	-3.62** (1.74)	-3.74** (1.53)
q=0.75	-5.68*** (2.03)	-5.03** (2.00)	-4.9*** (1.75)	-4.70** (1.86)
q=0.9	-3.47** (1.75)	-3.66** (1.81)	-3.31* (1.92)	-3.25 (2.24)
Native ancestry				
Mean	-4.33** (1.75)	-4.20** (1.68)	-3.91** (1.76)	-4.01** (1.70)
q=0.1	-5.06*** (1.68)	-4.58** (1.83)	-4.93*** (1.72)	-4.50** (1.78)
q=0.25	-5.28*** (1.20)	-4.29*** (1.18)	-3.22** (1.21)	-2.76** (1.21)
q=0.5	-3.48*** (0.75)	-3.41*** (0.75)	-3.86*** (0.92)	-3.96*** (0.84)
q=0.75	-2.81*** (0.90)	-3.12*** (0.79)	-3.42*** (0.77)	-3.47*** (0.78)
q=0.9	-1.34** (0.66)	-1.84*** (0.70)	-2.24*** (0.87)	-3.10*** (0.97)
SES				
Mean	0.96** (0.38)	0.30 (0.33)	-1.18* (0.65)	-0.67 (0.76)
q=0.1	1.01 (0.70)	0.42 (0.78)	-0.88 (0.8)	-0.75 (1.16)
q=0.25	1.11** (0.51)	0.37 (0.54)	-1.1* (0.62)	-1.15 (0.77)
q=0.5	0.73** (0.34)	0.40 (0.35)	-1.58*** (0.6)	-0.42 (0.82)
q=0.75	0.62* (0.36)	0.22 (0.36)	-0.37 (0.46)	-0.32 (0.67)
q=0.9	0.44 (0.28)	0.33 (0.30)	-0.14 (0.47)	-0.80 (0.87)

** and *** indicate $p < 0.1$, < 0.05 and < 0.01 , respectively.

Standard errors are in parentheses. q represents the quantiles of the child development rate.

^a Derived from the Bayley Infant Neurodevelopment Screener. Copyright © 2004. Harcourt Assessment Inc. Used with Permission. All rights Reserved.