Wealth Disparities for Early Childhood Anthropometrics and Skills: Evidence from Chilean Longitudinal Data[1]

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Abstract

We study wealth disparities in the formation of anthropometrics, cognitive skills and socio-emotional skills. We use a sample of preschool and early school children in Chile. We extend the previous literature by using longitudinal data, which allow us to study the dynamics of child growth and skills formation. Also, we include information on mother's and father's schooling attainment and mother's cognitive ability. We find that there are no significant anthropometric differences favoring the better-off at birth (and indeed length differences at birth to the disadvantage of the better-off), but during the first 30 months of life wealth disparities in height-for-age z scores (HAZ) favoring the better-off emerge. Moreover, we find wealth disparities in cognitive skills favoring the better-off emerge early in life and continue after children turn 6 years of age. We find no concurrent wealth disparities for and socio-emotional skills. Thus, even though the wealth disparities in birth outcomes if anything favor the poor, significant disparities favoring the rich emerge in the early post-natal period. Mother's education and cognitive ability also are significantly associated with disparities in skill formation.

Keywords. Wealth disparities, anthropometrics, cognitive skills, socio-emotional skills

JEL Classification: I14, I31, D30

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1. Introduction

An increasing number of studies, primarily using cross-sectional data, show that significant parental wealth/income disparities for child anthropometric measures and cognitive skills start early in life, in preschool and early school ages. Most of these studies are for high-income countries but they increasingly are for developing countries.

These studies, however, typically miss any potential dynamics in anthropometrics and skills formation. Also, they tend to lack relevant variables that could explain a great part of this relationship, such as mother's or father's schooling and cognitive skills. Moreover most of these studies focus on one type of child outcome, often height-for-age or cognitive skills, rather than comparing wealth disparities by anthropometric measures and by skill types, which may be important since the policy implications are likely to be different for different outcomes. Further many of these studies do not explore possibly important gender differences.

We contribute to the literature by addressing many of those shortcomings. We examine wealth disparities in anthropometric and skills outcomes using longitudinal data within a dynamic framework for both preschool and early school ages in Chile, a country characterized by fairly equal birth outcomes but high income inequality. We address the following questions: What are the extents of such disparities? Do the patterns differ for birth, the preschool and early school ages? How important are dynamic processes before and after school and since birth? Are there gender differentials with respect to both parental human capital and child outcomes? Do significant wealth disparities persist with control for parental human capital including cognitive skills in addition to schooling attainment? Do more disaggregated wealth categories (deciles rather than quintiles) reveal interesting patterns? Are the patterns similar for anthropometric, cognitive and behavioral outcomes?

This study contributes to the literature in five respects: First, we provide evidence using longitudinal data, which allow us to consider dynamics of wealth disparities.[6] Second, we use better control variables such as mothers' cognitive skills and child characteristics at birth, among others, that allows better identification of the extent to which the wealth disparities relationships persist beyond such factors. Third, we explore disparities for cognitive and socio-emotional skills of the child and compare those to anthropometric measures at birth and also during early childhood. Fourth, we consider gender differences, which are alleged to be important starting in early life. Fifth, we examine outcomes for Chile, a particularly interesting case study because there are relatively few, though increasing, studies of disparities for developing countries and Chile is further interesting because, as we show in the paper, there is relative equality in birth outcomes but substantial inequalities later in childhood.

Our results indicate that at birth there are almost no differences by wealth but the differences that exist in birth length disfavor the top wealth quintile. However, disparities favoring the better-off in height-for-age z scores (HAZ)[7] and in cognitive and socio-emotional skills emerge early in the post-natal period and are prominent by 30 months of age. Before preschool there are concurrent wealth differences in HAZ and cognitive skills even after controlling for lags of these outcomes and for mother's cognitive skills, however the concurrent wealth differences for socio-emotional skills disappear after adding control variables. Since we use a dynamic setting, controlling for lagged outcomes, wealth has a concurrent effect and a dynamic effect through the lagged outcome, we find that the concurrent effect decreases after children are older than 6 years of age for anthropometrics, but nor for cognitive skills, and even though there is no concurrent effect of wealth for socio-emotional skills, there is still always a dynamic effect for all the variables we analyze. At the same time, mother's education and mother's cognitive skills are highly associated with the formation of cognitive skills of

[6] Most previous wealth disparity estimates have been based on cross-sectional data. The few that use longitudinal data generally have not estimated dynamic relations of the type that we consider with very few exceptions (e.g., Mani 2012).
[7] Conventionally recumbent length is measured at birth and through the first two years of life and standing height is measured as children age. For simplicity we refer to the birth measurement as length and the post-natal measurements as height rather than using different terminology for different post-natal ages.

their children. For socio-emotional skills we find that disparities are less relevant, but mother's education and mother's cognitive skills are highly correlated with socio-emotional skills.

The paper is divided in five sections. The first is this introduction, the second reviews the literature, the third describes the data, the fourth presents the results and the fifth concludes.

2. Background

The importance of early human capital for economic and social well-being over the life cycle has received substantial and increasing attention in the literature. This research includes studies from in utero[8] to early childhood[9] to adolescence[10]. There is a general consensus that birth outcomes, especially birth weight, can impact schooling achievement, employment and earnings[11]. There also is a general consensus that early-life nutritional status and cognitive and socioemotional stimulation can have multiple impacts over the life cycle and across generations[12]. Additionally, there is a growing literature relating early cognitive and socio-emotional skills to adulthood outcomes (Cunha and Heckman, 2008), finding that both types of skills can have long-run effects.

In this context, it is relevant to study how early human capital varies by the socio-economic level of the household. Several papers –Paxson and Schady (2007), Fernald et al. (2011), Fernald et al. (2012), Schady et al. (2015), Rubio-Codina et al. (2015), Boo (2016), Reynolds et al. (2017) – among others have found consistently that there are strong relationships between indicators of socioeconomic status and early-life

[8] Barker (1992); Almond (2006); Majid (2015); Liu et al (2017).
[9] Hoddinott et al (2008, 2013); Behrman et al (2009); Maluccio et al (2009); Stein et al (2010, 2013); Martorell et al. (2010); Kuzawa et al. (2012); Norris et al (2012); Walker et al (2012); Crookston et al (2013); Gertler et al (2014); Aurino et al (2017); Roberts and Stein (2017).
[10] Heckman, Stixrud and Urzua (2006); Stein et al (2016); Schott et al (2017)
[11] Conley and Bennett, (2000); Behrman and Rosenzweig, (2004); Currie and Almond (2011); Torche and Echevarría (2011); Torche and Conley (2016)
12 Hoddinott et al (2008, 2013); Victora et al (2008); Behrman et al (2009); Maluccio et al (2009); Stein et al (2010, 2013); Martorell et al (2010); Walker et al (2011); Kuzawa et al (2012); Norris et al (2012); Crookston, et al. (2013); Gertler et al (2014)

human capital. Nonetheless, as noted in the introduction, these studies have a number of limitations that we address in this paper.

We study the wealth disparities for anthropometrics and cognitive and socio-emotional skills using longitudinal data for Chile, which is a country that exhibits high-income inequality, but very good health outcomes on average. Chile has one of the most unequal income distributions in the Latin American and Caribbean (LAC) region, which in turn has the greatest inequality among the world's major regions. According to the World Bank, Chilean inequality is only surpassed in LAC by Honduras, Colombia, Brazil, Guatemala and Panama. In addition, according to 2016 OECD data Chile is the most unequal economy in OECD countries with a Gini index of 0.465, followed by Mexico and the United States with 0.459 and 0.394 respectively. In contrast, in 2015, according to the World Bank Chile had mortality rates for children under 5 years of age of 8.1 per 1000 live births, which is much lower than the LAC average of 17.9, and only slightly higher than the OECD average of 6.9.

These statistics raise the question of what happens in Chile between birth and adulthood that transforms relatively equal initial human capital into one of the most unequal countries in the globe? Our research shows that there are no differences that favor the better-off at birth, who to the contrary, average shorted lengths at birth, but that fairly early in the postnatal period differences that favor the better-off over the poorest are observed in anthropometrics and cognitive and socio-emotional skills. We also find that the largest disparities are for cognitive ability. This is consistent with a relative developed health system that dates back to at least the mid 1950's[13] and that covers well prenatal care, but less well postnatal growth, health and skill acquisition. Effectively, families play much larger roles in postnatal than prenatal development and their roles vary considerably with wealth.

[13] Contreras & Puentes, (2016)

3. Data

This study uses data from the first (2010) and second (2012) rounds of the Early Childhood Longitudinal Survey (Encuesta Longitudinal de la Primera Infancia, ELPI). The survey is representative of the Chilean population under five years of age and was created to gather information about children in the first few years of life for the purpose of designing and assessing different public policy programs.

The survey consisted of two information-gathering visits; on the first a socio-demographic survey was taken in the household of each child included in the survey. On the second visit, three instruments were applied to evaluate cognitive, socio-emotional and physical aspects. The survey was administered by psychologists with experience in infant evaluations and/or psychological tests.

For anthropometrics, we use height-for-age z scores (HAZ) and weight-for-height z scores (WHZ) based on the World Health Organization (WHO 2006; de Onis et al 2007) standards. HAZ is widely-used as an indicator of chronic or longer-run nutritional status and WHZ is widely-used as an indicator of shorter-run nutritional status.

For child skills, we use two tests: The Peabody Picture Vocabulary Test (PPVT) and the Child Behaviour Check List (CBCL). The PPVT test is an adaptation of the Peabody Picture Vocabulary Test that was designed for Spanish-speaking children. It is a measure of auditory vocabulary that is internally valid and consistent and has been used in several international studies (Coddington et al 2014; Contreras and Gonzalez 2015; Shady et al 2015). The PPVT was administrated to children between 30 and 60 months of age in 2010 and to children between 30 and 84 months of age in 2012. The CBCL is a test that measures behavioral and socio-emotional abilities of children, and allows identification of problems such as anxiety, autism, violent behaviors and attention deficits that children might have. The CBCL was administrated to children between 18 and 60 months of age in 2010 and to children between 18 and 84 months of age in 2012. For the CBCL test we note a caveat. The test is designed for children younger than 72 months, but since some children in 2012 were older than 72 months, the test was changed and adapted for older children; we call this new test CBCL2, and the test for younger than 72 months as CBCL1. Despite being a somewhat different test, CBCL2 measures the same traits as CBCL1.

Additionally, we use Battelle's Development Inventory, which is a test based on the concepts of developmental milestones and includes several domains: personal, social, adaptive, fine and gross motor, communication and cognitive (Barros et al, 2010). The test was administrated to children between 6 and 24 months of age, and for this article we use the social and cognitive domains.[14]

One important advantage of the ELPI is that has a measure of mother's cognitive ability, which is not available and therefore not considered in previous studies. In particular, we use the Wechsler Adult Intelligence Scale (WAIS) test that measures the overall intelligence of individuals 16 to 64 years of age. This test is divided into a digit span and a vocabulary subtest.[15]

The second round of the ELPI in 2012 tried to interview the children that were interviewed in 2010.[16] To achieve the goal of having a representative sample of children starting from birth in 2010, a refreshment sample of children 0-2 years of age was added. Because of our interest in longitudinal dynamics, we do not include the 2012 refreshment sample in our analysis.

In Table 1 we show the descriptive statistics for the three samples used in the paper. The first sample includes children with information on anthropometric measures for 2010 and 2012, the second sample considers children with information on PPVT for 2010 and 2012 and the third sample considers children with information on CBCL for 2010 and 2012. The three samples have different sizes since the PPVT and CBCL tests

[14] More details about the tests can be found in the appendix

[15] Apfelbeck and Hermosilla (2000)

[16] We use in all specifications sampling weights that correct for attrition for the whole sample. Our sample has some additional restrictions compared to the whole sample, such as using information only for biological mothers and requiring that children in our sample have anthropometrics measures for both years. The attrition rate of our sample was 25% and for the overall sample was 21%

cover different age ranges and the data requirements are different. For instance, in the first sample that requires that children have information on anthropometrics for both years, there are 8,757 children with information on PPVT in 2012, but some of these children did not have information on the PPVT in 2010. That is why in the second sample there are 4,577 children with information on PPVT for 2012, who also took the test in 2010. A similar analysis holds for the third sample and the number of observations for CBCL1 and CBCL2.

Overall, the first sample is the largest and includes information for 8,832 children, the second sample consists of 4,577 children and the third sample consists of 7,058 children. As mentioned before, in the third sample there are two CBCL tests: the first one has information for 5,660 children and the second one has information for 1,398 children. In general, the three samples have similar characteristics; for instance, the average grades of schooling attained of the mothers are 11.4, 11.3 and 11.4 respectively. There are differences in height and weight, but this is due to the age differences in the samples.

Our main interest is to study the anthropometric and skills wealth disparities. The ELPI asks households for several household assets, which jointly with the information on whether the family owns a household allow us to build a wealth index using principal component analysis. We use this index to generate wealth quintiles.[17] We also use household income to perform a robust analysis and all the main results hold.

[17] The list of assets included in the calculations are: Refrigerator, laundry machine, VCR or DVD player, microwave, water heater, video camera, paid internet connection, desktop computer, laptop computer, tv cable and owning a house.

Table 1: Descriptive Statistics

Variable	Anthropometric Longitudinal Sample		PPVT Longitudinal Sample		CBCL Longitudinal Sample	
	Obs	Mean	Obs	Mean	Obs	Mean
PPVT 2012	8,757	103.2	4,577	105.9	7,001	104.0
CBCL 1 2012	7,423	55.0	3,181	54.2	5,660	54.7
CBCL 2 2012	1,399	56.4	1,388	56.3	1,398	56.4
Child's Height 2012	8,832	107.7	4,577	113.5	7,058	110.2
Child's Weight 2012	8,832	19.9	4,577	22.1	7,058	20.8
Child's Age 2012	8,832	56.6	4,577	66.9	7,058	60.9
Male Child	8,832	0.5	4,577	0.5	7,058	0.5
Mother´s Schooling Attainment	8,734	11.4	4,526	11.3	6,975	11.4
Numeric WAIS	8,822	7.0	4,573	6.9	7,055	6.9
Vocabulary WAIS	8,822	8.1	4,573	8.1	7,055	8.1
Mother´s Age 2012	8,754	31.7	4,533	32.6	6,993	32.0
Wealth Quintile	8,832	2.9	4,577	2.9	7,058	2.9

The Anthropometric Longitudinal Sample refers to the simple that has non-missing data for anthropometric measures (Height and Weight) for 2010 and 2012. The PPVT Longitudinal Sample refers to the sample that, besides anthropometric measures, has PPVT scores for both years. The CBCL Longitudinal sample corresponds to the sample that has anthropometric measures for both years, CBCL 1 in 2010 and either CBCL 1 or 2 in 2012.

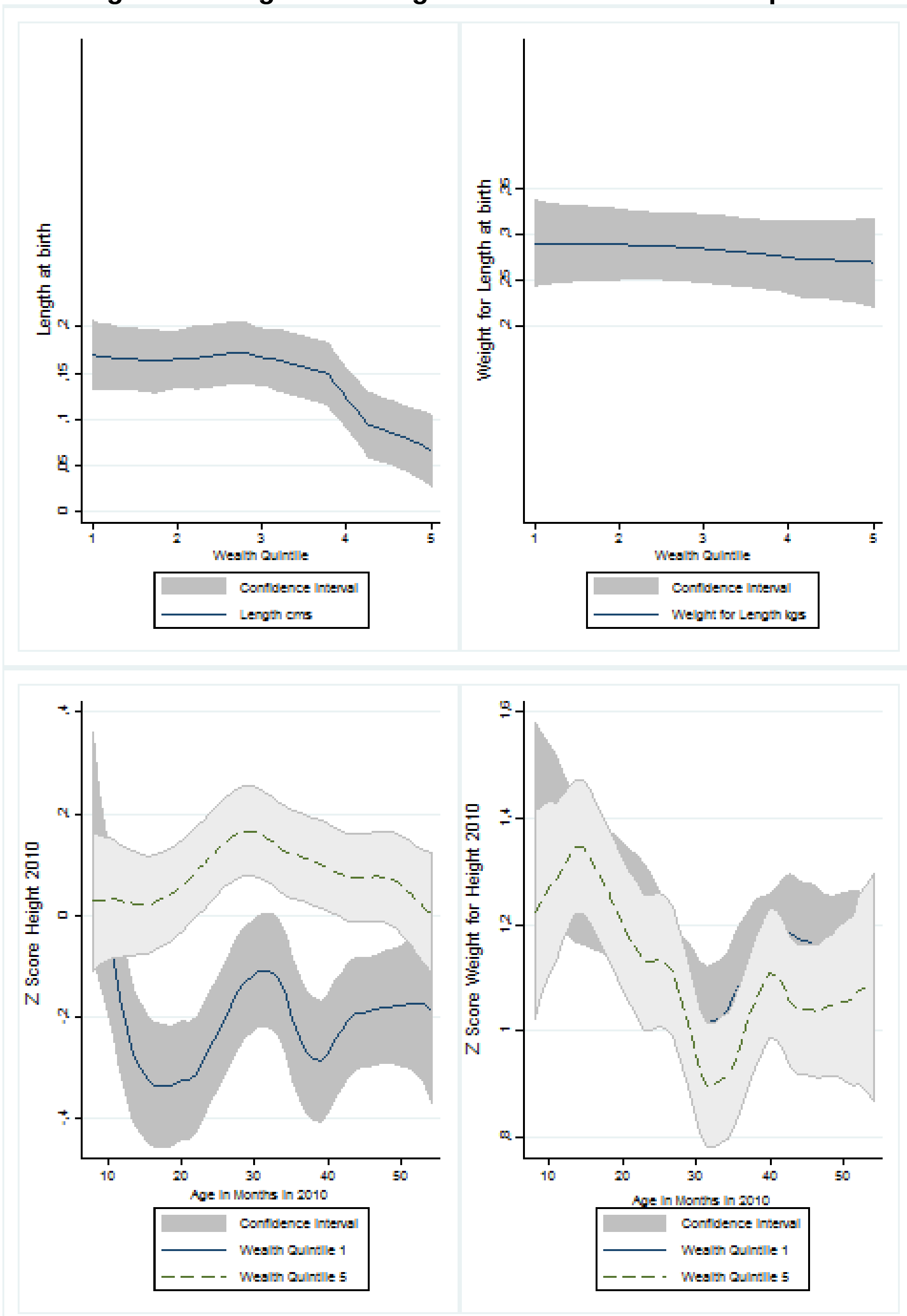
4. Wealth disparities.

We now empirically examine the wealth disparities in HAZ, WHZ, cognitive skills and socio-emotional skills. First, we present some graphs comparing the averages of the child outcomes for the first and fifth wealth quintiles in 2010 that are useful to show at what age gaps emerge. Then, we use regressions to check if any wealth disparities in the graphs hold after controlling for some relevant variables.

We start with the anthropometric measures, HAZ and WHZ. In 2010, ELPI collected information about length and weight at birth retrospectively, and current height and weight were measured on site for children between 7 and 60 months. We present in the first panel of Figure 1 the information at birth and in the second panel of Figure 1 the 2010 information. At birth there are almost no differences in HAZ and WHZ by quintile except that children in the poorest quintile are slighter longer than children from the wealthiest quintile. This is somewhat surprising and may reflect a higher prevalence of Cesarean births and shorter gestation periods for the fifth than for the other quintiles.[18] However, by 7 months of age there is no significant difference in HAZ between the first and the fifth quintile and by 10 months of age differences in HAZ between the poorest and richest quintiles favoring the latter are emerging. These differences reach a peak around 20 months of age, and then decrease until there is not a significant difference at about 50 months. For WHZ, we observe that there are no relevant differences by quintile at birth or in the 7-50 month range.

[18] According to the data, in the first quintile Cesarean births are about one third and in the richest quintile slightly above 50%.

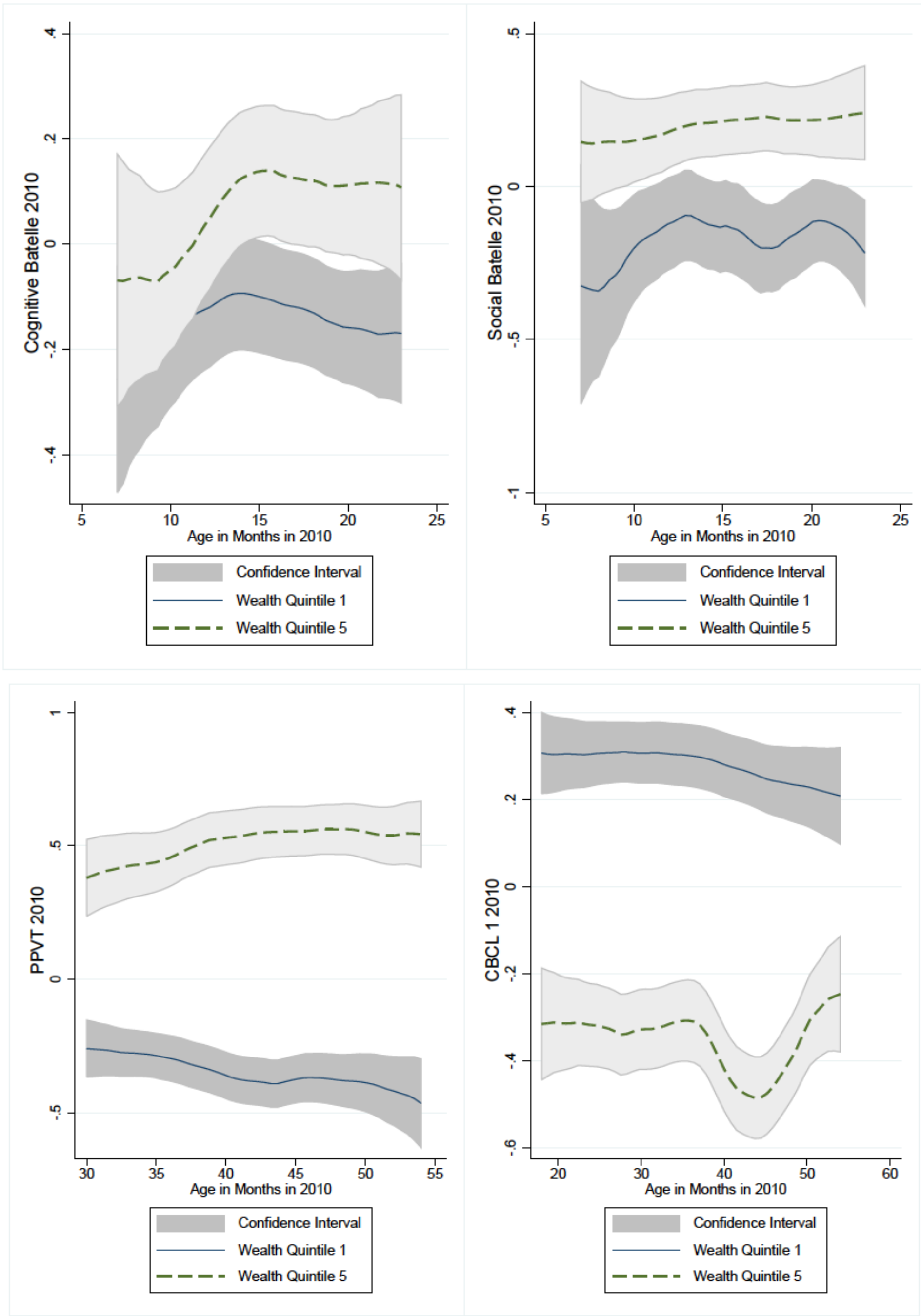
Figure 1: Length and weight at birth across wealth quintiles



Notes: Anthropometric Measures are presented using Z scores.
Source: Authors' calculations using ELPI 2010 and 2012

To study differences in cognitive skills and socio-emotional skills at early ages, we use the Battelle test, which provides information from ages 6 to 24 months, and then the PPVT and CBCL tests, which provide information for older ages. Higher Battelle or PPVT scores indicate higher cognitive skills. In contrast, higher CBCL scores indicate lower socioemotional skills. In Figure 2, first panel, we observe that also by 15 months of age there are some significant differences in cognitive skills between the poorest and richest quintile, and the differences in social behavior start even at 6 months of age. Moreover, the cognitive differences increase for older children in the 30-50 month age range, though socio-emotional skills have a roughly similar disparity at age 20 and at age 50 months.

Figure 2: Test scores gaps between wealth quintiles 1 and 5 versus ages in months



Notes: Tests are presented using Z scores.
Source: Authors elaboration using ELPI 2010 and 2012

Regressions

We know turn to a regression model to study the wealth disparities in anthropometrics and skills. We begin with the following model:

$$Y_i = \alpha_0 + \sum_{j=2}^{5} \beta_j A_{i,j} + \epsilon_i \quad (1)$$

Where Y_i is the standardized outcome (anthropometric or skill measure) of child i, $A_{i,j}$ is a dummy variable that is 1 if the family of child i is in asset quintile j and 0 if not and ϵ_i is the error term. The reference (excluded) quintile is the first quintile.

Equation (1) allows us to study the gross wealth disparities. However there are many variables that could be confounding this relationship. For instance, it could be the case that most of the wealth disparity disappears if mother's schooling, which is positively related to both wealth and child outcomes, is included. To study the potential links between the relationship of wealth and child outcomes we include a vector of observed child characteristics (X_i) such as length at birth, birth weight and a set of parent characteristics (R_i) such as parental schooling and numerical and verbal WAIS test scores.[19] Moreover, we include the lag of the child outcome, which allows us to study if the wealth disparities have dynamic associations with child outcomes. This also ties in our study with the controversy about whether there is catch-up growth after 2-3 years of age (Victora et al. 2008, 2010; Prentice et al. 2013; Mani et al. 2012; Crookston et al. 2013; Schott et al. 2013; Leroy et al. 2013, 2014; Lundeen et al 2014). If ∂ is not significantly different from one there is no catch-up, if ∂ is not significantly different from zero there is complete catch-up and if If ∂ is significantly greater than zero and less than one there is partial catch-up. These changes lead to the following specification:

$$Y_{i,2012} = \alpha_0 + \sum_{j=2}^{5} \beta_j A_{i,j,2010} + \theta X_{i,2010} + \gamma R_i + \partial Y_{i,2010} + \epsilon_{i,2012} \quad (2)$$

[19] In the cases when there is missing information on covariates, we impute a value with the mean of the covariate for the non-missing observations, including also a dummy variable to indicate that there is an imputed missing value in that observation. For father's schooling, we use information when the father lives in the same household as the child; if the father lives elsewhere, we impute schooling using the procedure described above.

In equation (2) wealth disparities are captured by the parameters β_j, which inform about the concurrent wealth effect. But even if β_j is not statistically significant, wealth might still play a role through ∂ and the wealth disparities for $Y_{i,2010}$.

Thus, our approach consists of estimating alternative reduced-form linear regression models with children's anthropometric and skills as dependent variables that control in some alternatives for individual children's characteristics, parental characteristics and lagged effects. Including the additional variables in equation (2) in comparison with equation (1) allows us to go beyond much of the previous literature by investigating to what extend the disparities estimated in equation (1) are attenuated by including child and parental characteristics and by allowing for dynamics. Note that because we define our dependent variables all to be z scores, the right-side coefficient estimates can be compared across child outcomes because they all give the impact of a one unit change in the relevant right-side variable on standard deviations in child outcomes in the reference populations.

To study the wealth disparities by age in anthropometrics, we divide the sample into three sub-groups: children between 7 and 30 months of age, children between 30 and 71 months of age and children between 72 and 83 months of age. We split the sample into these groups to first study the period between 7 and 30 months of age that is claimed to be a critical window for some important dimensions of child development. Then the second and third groups allow us to compare with the skills specifications that are divided before and after being 72 months of age, which is the age for starting primary school. For cognitive and socio-emotional skills we divide the sample into two groups, since testing starts at older ages, PPVT at 24 months and CBCL at 18 months. The groups are before and after (including) 72 months, to compare children before and after the school-starting age.

In the following tables we present the results for specifications (1) and (2). We cluster errors at the regional level to adjust for potential common shocks[20].

[20] In 2012 Chile was divided into 15 regions.

Anthropometric results

Table 2 shows the results for HAZ, for WHZ we present the results in the appendix. For the initial ages we use information from the 2010 ELPI, in which case it is not possible to control for lagged postnatal HAZ. For ages 33 months and older in columns three to six, we use information collected in the 2012 ELPI, in which case we can include lagged postnatal anthropometrics. Nonetheless we always include length and weight at birth. In the first and second column of Table 2, for children between 7 and 30 months of age, we observe a considerable gross wealth gap (column (1)), Children from the wealthiest quintile have on average 0.33 higher HAZ than children from the poorest quintile. In column (2), when all the covariates are included, the difference between the poorest and wealthiest quintile is 0.24.

For older children, the concurrent wealth disparities decrease and eventually disappear when the additional controls are included. For children between 33 and 71 months of age, the gross concurrent wealth gap between children of the poorest and wealthiest quintile is 0.27, and when all the covariates are included is equal to 0.11 (columns (3) and (4), Table 2). For children between 72 and 83 months of age, the gross concurrent wealth gap is 0.20, but when all covariates are included, the gap is positive, but no longer statistically significant (columns (5) and (6), Table 2).

In terms of the other covariates, the lagged HAZ are significantly nonzero so there is some persistence, but significantly less than 1.0 so there also is some partial catch-up. The coefficient estimate for lagged HAZ is larger for the older age range, suggesting greater persistence with age. Few non-anthropometric variables are significant for HAZ: mother's schooling positively for children younger than 72 months of age and negatively for older children, and WAIS also negatively for older children. These results suggest a convergence process over time. The gaps associated with wealthier families or more educated/skilled mothers tend to disappear for older children. One potential reason for this finding is access to nutrients and health provision, which tends to reduce any socioeconomic gap with age. Indeed, the country has established a massive food program starting at nursery school throughout the whole educational system. Given that most Chilean children begin to attend pre schools after two years of age; this may explain the convergence in HAZ across socioeconomic and educational status.

For WFH we present the results in the appendix and only for children younger than 60 months because there are not comparable WHO z-scores available for older children. The results in the appendix (Table A1) indicate that wealth disparities appear when controlling for other factors, moreover for children between 33 and 60 months of age, the gap is 0.45 -- four times the gap found for HAZ for children of similar ages.

Table 2: HAZ estimations

	Cross Section for Children Aged 7 to 30 months in 2010.		Longitudinal Estimation for Children aged 33 to 71 months in 2012		Longitudinal Estimation for Children aged 72 to 83 months in 2012	
VARIABLES	Child's Z-Height 2010	Child's Z-Height 2010	Child's Z-Height 2012	Child's Z-Height 2012	Child's Z-Height 2012	Child's Z-Height 2012
	(1)	(2)	(3)	(4)	(5)	(6)
Quintile = 2	0.027	-0.007	0.056	0.026	0.034	0.008
	(0.063)	(0.068)	(0.040)	(0.028)	(0.059)	(0.038)
Quintile = 3	0.178***	0.108*	0.148***	0.052*	0.166**	0.087
	(0.055)	(0.061)	(0.020)	(0.026)	(0.062)	(0.057)
Quintile = 4	0.220***	0.143**	0.169***	0.062*	0.223***	0.103*
	(0.041)	(0.053)	(0.038)	(0.033)	(0.059)	(0.053)
Quintile = 5	0.333***	0.244***	0.265***	0.112***	0.202**	0.093
	(0.050)	(0.065)	(0.030)	(0.030)	(0.094)	(0.063)
Mother's Schooling		0.027***		0.006**		-0.013*
		(0.007)		(0.003)		(0.007)
Father's Schooling		-0.004		-0.003		0.000
		(0.008)		(0.004)		(0.005)
Numeric WAIS		-0.002		-0.002		0.005
		(0.008)		(0.003)		(0.004)
Vocabulary WAIS		0.001		0.001		-0.012**
		(0.006)		(0.003)		(0.005)
Child's Height 2010 (Z)				0.459***		0.649***
				(0.011)		(0.017)
Height at Birth Z		0.250***		0.116***		0.076***
		(0.021)		(0.012)		(0.023)
Weight at Birth Z		0.042		0.007		-0.004
		(0.032)		(0.012)		(0.020)
Constant	-0.235	-0.568*	0.256	0.204*	0.543	0.657
	(0.336)	(0.297)	(0.213)	(0.097)	(0.795)	(0.642)
Observations	4,424	4,418	7,429	7,421	1,403	1,401
R-squared	0.026	0.091	0.024	0.316	0.027	0.459

Standard errors clustered at a regional level
*** p<0.01, ** p<0.05, * p<0.1

Skills results

For the analysis of the wealth disparities for a cognitive test (PPVT) and a socio-emotional test (CBCL), we divide the sample in two, before and after 72 months of age. We have information in 2012 starting at 50 months of age for children with PPVT data, and for children 39 months and older with CBCL data. In 2010 PPVT was collected for children between 24 and 60 months of age, and CBCL was collected for children between 18 and 60 months of age.

Columns (1) and (2) in Table 3 give the estimates for the younger sample on the PPVT test. We observe in column (1) that there are relatively big differences by wealth quintile: children in the wealthiest quintile have on average 0.70 higher PPVT z scores than children in the poorest quintile. Moreover, children in the fifth quintile have 75% more than the difference of children of the first quintile compared to children in the fourth quintile. Most of the difference is from children in the wealthiest 10%, who have 0.88 SD higher scores than children in the 10% poorest decile (see Table A2 in the Appendix). In column (2) all covariates are included and children in the fifth quintile obtain 0.17 higher scores on the PPVT test compared to children in the poorest quintile and 0.23 higher scores when we compare the richest decile to the poorest decile. In this case, we observe that children in the fifth quintile obtain about 40% more than the differential between children from the first quintile and children in the fourth quintile.

In columns (3) and (4) of Table 3 we observe that for older children there are still big differences by quintile when no other covariates are included (column (3)): children in the fifth quintile obtain 0.7 higher scores than children in the first quintile. When all covariates are included the differences are still large, at 0.15, but the parameter only is marginally significant at the 10% level. However, when we analyze by deciles, we find even larger differences at older ages, since the difference between children from the richest decile and children in poorest decile is 0.42. For this age group, we find that children in the fourth quintile tend to have better test scores than children in the fifth quintile; when analyzing by decile, we observe that this is mostly due to the smaller difference between the 9^{th} decile compared with the 7^{th}, 8^{th} and 10^{th} deciles (see Table A2).

For the rest of the covariates, the coefficient estimates of the lagged test scores as for the lagged anthropometrics in Table 3 are significantly nonzero indicating some persistence in wealth disparities and significantly less than 1.0 indicating there is some partial catch-up. They also increase with age, as do the lagged effects for anthropometrics, from 0.32 for the younger to 0.38 for older children, an increase that might in part explain the lower concurrent differences by quintiles for older than for younger children. But note that the lagged coefficients are smaller for the PPVT scores than for the anthropometrics, indicating greater catch-up for these test scores than for anthropometrics. Mother's schooling is consistently related to cognitive skills; one additional grade of mother's schooling attainment is associated with increased cognitive skills of 0.03 for younger and older children. Though mother's schooling is significant, note that it would require gaps of 5-6 grades in mother's schooling to account for the same disparity as between the top and bottom wealth quintile. On the other hand, father's education and mother's cognitive ability only have significant associations before children are of school age.

To study if some of the early disparities on HAZ have an impact on cognitive skills and the wealth disparities, we also included in the specifications the lagged HAZ and WHZ. We find that even though the lagged anthropometrics have statistically significant coefficient estimates, the changes in estimated wealth disparities are very small (see appendix Tables A4 and A5).

Table 3:PPVT estimations

VARIABLES	Longitudinal Estimation for Children aged 52 to 71 months in 2012		Longitudinal Estimations for Children aged 72 to 83 months in 2012	
	PPVT 2012 Z	PPVT 2012 Z	PPVT 2012 Z	PPVT 2012 Z
	(1)	(2)	(3)	(4)
Quintile = 2	0.156**	0.045	0.101	0.004
	(0.065)	(0.051)	(0.068)	(0.080)
Quintile = 3	0.300***	0.064	0.351***	0.117*
	(0.069)	(0.041)	(0.046)	(0.065)
Quintile = 4	0.407***	0.122**	0.578***	0.232***
	(0.085)	(0.046)	(0.077)	(0.077)
Quintile = 5	0.698***	0.167***	0.700***	0.152*
	(0.071)	(0.042)	(0.059)	(0.076)
Mother's Schooling		0.032***		0.029***
		(0.007)		(0.008)
Father's Schooling		0.022***		0.005
		(0.005)		(0.009)
Numeric WAIS		-0.005		-0.001
		(0.006)		(0.007)
Vocabulary WAIS		0.015**		0.010
		(0.006)		(0.008)
PPVT 2010 Z		0.321***		0.388***
		(0.017)		(0.021)
Height at Birth Z		0.009		0.014
		(0.016)		(0.023)
Weight at Birth Z		-0.022		-0.008
		(0.020)		(0.035)
Constant	1.321***	0.547	0.133	-0.841
	(0.354)	(0.495)	(0.799)	(0.672)
Observations	3,185	3,183	1,392	1,390
R-squared	0.100	0.226	0.125	0.283

Standard errors clustered at a regional level
*** p<0.01, ** p<0.05, * p<0.1

For socio-emotional skills (CBCL) we find that there are in general lower gross wealth disparities than for PPVT (Table 4) and the concurrent wealth effect is not statistically significant when all covariates are included (For CBCL, note again that a lower score implies that the child has higher socio-emotional skills.) Children from the wealthiest quintile have on average 0.5 lower scores than children from the poorest quintile. There are various similarities with the results for cognitive skills. First, children from the fifth quintile obtain scores almost twice lower than children from the fourth quintile. Second, the disparities are highly reduced when all the covariates are included; in column (2), the difference is relatively small at 0.06 and no longer statistically significant.[21].

For older children, between 72 and 83 months of age, the concurrent wealth disparities start at a lower level, 0.37 if no covariates are included, and there are no significant concurrent wealth effects when all covariates are included (column (4), Table 4). In terms of the dynamics, for the socio-emotional skills there is less persistence as children get older, the opposite of what happens to cognitive skills. The coefficient for the lag of the CBCL scores goes from 0.38 for children younger than 72 months, to 0.31 for children older than 72. In the appendix (Tables A5) we show that when lagged HAZ and WHZ are included in the estimation, the wealth disparities do not change, indicating that disparities on anthropometrics are not associated with disparities in socio-emotional skills.

With respect to the rest of the covariates, mother's schooling and WAIS have positive associations with socio-emotional skills for children of all ages.

Finally, there are many important gender differences starting early in life. In our sample, for example, girls systematically do better on Battelle, PPVT and CBCL1. Therefore we

[21] The analysis by decile is presented In table A3 and we observe that for the 8th decile there are significant differences compared with the poorest decile, but there are no statistically significant differences for the 9th and 10th decile.

explored whether there are systematic differences in wealth disparities by gender. We found significant differences about as frequently as would be expected by chance (results not presented, available upon request).

Table 4: CBCL Estimations

	Longitudinal Estimation for children aged 39 to 71 months in 2012		Longitudinal Estimation for children aged 72 to 83 months in 2012	
VARIABLES	CBCL 2012 Z	CBCL 2012 Z	CBCL 2012 Z	CBCL 2012 Z
	(1)	(2)	(3)	(4)
Quintile = 2	-0.122*	-0.042	-0.007	0.048
	(0.057)	(0.058)	(0.128)	(0.106)
Quintile = 3	-0.194***	0.001	-0.052	0.104
	(0.035)	(0.036)	(0.100)	(0.110)
Quintile = 4	-0.295***	-0.048	-0.279**	-0.021
	(0.054)	(0.047)	(0.112)	(0.106)
Quintile = 5	-0.505***	-0.064	-0.369***	0.030
	(0.024)	(0.045)	(0.081)	(0.130)
Mother's Schooling		-0.021***		-0.022**
		(0.006)		(0.009)
Father's Schooling		-0.007		-0.003
		(0.007)		(0.017)
Numeric WAIS		-0.003		0.011
		(0.003)		(0.010)
Vocabulary WAIS		-0.012***		-0.028**
		(0.004)		(0.010)
CBCL 2010 Z		0.379***		0.314***
		(0.019)		(0.032)
Height at Birth Z		-0.026		-0.006
		(0.019)		(0.022)
Weight at Birth Z		0.029**		0.007
		(0.012)		(0.033)
Constant	1.326**	1.958***	1.357*	2.237***
	(0.565)	(0.476)	(0.677)	(0.561)
Observations	5,660	5,658	1,396	1,395
R-squared	0.068	0.224	0.078	0.203

Standard errors clustered at a regional level
*** p<0.01, ** p<0.05, * p<0.1

5. Conclusions

We use longitudinal data to study the relevance of wealth disparities in a dynamic model of anthropometric and skill formation for Chile. This is an interesting case because there have been relatively few studies of wealth disparities for developing countries and because, as we show, there are not wealth disparities at birth that favor richer quintiles in Chile for the major anthropometric indicators of birth length and weight.

We find that wealth disparities still have important predictive power after controlling for a number of relevant variables for disparities in the formation of cognitive skills for children starting in the second year of life and continuing between 50 and 83 months of age. Wealth has smaller concurrent associations with differentials in anthropometrics for children starting in their second year and continuing through 72 months of age, but not for still older children. For socio-emotional skills we find that concurrent wealth does not affect those skills for children between 39 and 71 months of age. Our results also indicate that mother's schooling and cognitive ability are important correlates of anthropometric and skill formation. That both variables are significant might indicate that there is some genetic transmission of abilities and/or that more education provides tools to mothers that help them to raise their children. Another key result is that initial conditions, measured as height and weight at birth, do not affect skill formation, which in part occurs because there are not significant differences at birth that favor the richest quintile – indeed, for height, they favor the poorer over the richest quintile. The latter pattern is reversed in the months after birth. Apparently the Chilean ante-natal care system works well to avoid discrepancies in birth outcomes disadvantageous for the poor. But, postnatally, disparities favoring children from richer families occur by the second year of life. And even though some the disparities in anthropometrics reach a peak at about 20 months and decline thereafter, this age pattern suggests that postnatal subnutrition and infectious disease prevalence disadvantages poor children during what is thought to be a critical window up to 24-36 months during which these factors also constrain neurodevelopment with life-time implications (Victora et al. 2008, 2010; Walker et al. 2011; Richter et al. 2017). Further, we find that the lags of the skills tests are significantly greater than zero and less than one, which highlights the dynamic nature of skill formation with some persistence but also partial catch-up so that disparities by wealth still persist with age but become smaller for older children. Indeed, the catch-up is greater for skills than for anthropometrics. Finally, though there are gender differences in the child outcomes favoring girls, we find no gender differences in wealth disparities.

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8. Appendix

Test Descriptions

Peabody Picture Vocabulary Test (PPVT)

The test is an adaptation for Spanish-speaking children of the Peabody Picture Vocabulary Test. It offers a measure of auditory vocabulary that is internally valid and consistent, and has been used in several international studies.

This psychometric test is intended to measure the auditory reception capacity of children 30 to 60 months old. It is easy to apply and as it requires no reading or writing skills it can be applied to preschool-aged children. The test contains 125 laminated sheets, each of which contains 4 pictures. The examiner shows the child each of the sheets and says a word out loud. After hearing the word, the child must select the image that best illustrates its meaning. The test is applied until it the child is not able to identify 6 out of 8 pictures.

The results are then standardized according to the age group of those interviewed using standards for Mexico and Puerto Rico. The standardized scale of the test ranges from 55 to 145 points, with scores ranging from extremely low to extremely high (Dunn et al. 1986).

Child Behaviour Check List: CBCL

The Child Behaviour Check List (CBLC) assess behavior and socio-emotional competencies of the child as reported by the parents, and can be used to identify problematic areas in child development: emotional reactivity, anxiety/depression, somatic complaints, autism, attention problems, aggressive behavior, and sleep problems. In addition to a total score, which assess all seven areas simultaneously, each area can be studied separately. Finally, the first four areas (emotional reactivity, anxiety/depression, somatic complaints, and autism) are grouped into an internalization category, and the next two (attention problems and aggressive behavior) into an externalization category. The scale is reversed, then a lower scores indicates higher socio-emotional skills.

Battelle's Developmental Inventory: BDI

It is defined as a battery to evaluate fundamental developmental skills in Children between the ages of birth and eight years. It has 5 components, but we use two: Cognitive and Social.

The cognitive component evaluates memory, reasoning, conceptual development. For instance, children have to identify and solve problems, compare objects, using size or color or putting a puzzle together.

The social component evaluates the capacities and characteristics that allow the child establish meaningful social interaction. For instance, the test evaluates interactions with adults, ability to express feelings, tolerate frustration, interaction with peers among other aspects.

Wechsler Adult Intelligence Scale (Adults) (WAIS)

The test of the two subscales of the Weschler Adults Intelligence Scale (WAIS) developed by Apfelbeck and Hermosilla (2000) involves vocabulary and digit retention, more commonly known as language and mathematics. This allows researchers to obtain the intellectual quotient, which is defined as the ratio of the achievement of the subject and the average achieved by the age group.

This test allows one to ascertain whether the skills evaluated are extremely low, border-line, low average, average, high average, superior or very superior. The test provides a gross score that is transformed into the standard results in order to conduct the aforementioned classifications. The abilities measured in each test are listed below:

Digit retention sub-scale: This is a two-part test with the sections applied consecutively: digits in the same order and retention of digits in inverse order. It measures the performance of work or operational memory and the information processing speed. In addition, short-term auditory memory, sequencing, independence from distraction, facility with numbers and mental alertness are evaluated. A normal score indicates normal functioning in these areas and an excellent level implies rapid adaptation to stimulus and flexibility of cognitive adaptation.

Vocabulary sub-scale: Evaluates the cultural level, schooling, the capacity to receive new information, store it and use it correctly, receptivity of new ideas, associativity, classification and conceptualization.

Table A1: WFH Estimations

	Cross Section Estimation for children aged 7-30 months in 2010		Longitudinal Estimation for Children aged 33-60 months in 2012	
VARIABLES	Weight for Height 2010 (Z)	Weight for Height 2010 (Z)	Weight for Height 2012	Weight for Height 2012
Quintile = 2	0.0446	0.0592	0.0853	0.0141
	(0.0594)	(0.0594)	(0.0853)	(0.0858)
Quintile = 3	0.0834	0.122*	0.389***	0.293***
	(0.0621)	(0.0604)	(0.0687)	(0.0819)
Quintile = 4	0.0579	0.123	0.325***	0.264***
	(0.0591)	(0.0771)	(0.0929)	(0.0696)
Quintile = 5	0.0196	0.144*	0.405***	0.456***
	(0.0411)	(0.0679)	(0.0496)	(0.0725)
Mother's Schooling		-0.0131*		0.0235
		(0.00611)		(0.0163)
Father's Schooling		-0.00734		-0.0303**
		(0.00552)		(0.0107)
Numeric WAIS		-0.000672		0.0106
		(0.00735)		(0.00688)
Vocabulary WAIS		-0.00576		-0.00396
		(0.00950)		(0.00633)
Weight for Height 2010 (Z)				0.820***
				(0.0297)
Height at Birth Z		-0.0442*		0.279***
		(0.0246)		(0.0266)
Weight at Birth Z		0.237***		0.0762
		(0.0172)		(0.0623)
Constant	1.950***	2.142***	-2.253*	-3.918***
	(0.353)	(0.357)	(1.114)	(0.734)
Observations	4,424	4,418	5,280	5,272
R-squared	0.019	0.049	0.341	0.475

*** p<0.01, ** p<0.05, * p<0.1

Standard errors clustered at a regional level

Table A2: PPVT Estimations, Deciles

	Longitudinal Estimation for Children aged 52 to 71 months in 2012		Longitudinal Estimations for Children aged 72 to 83 months in 2012	
VARIABLES	PPVT 2012 Z	PPVT 2012 Z	PPVT 2012 Z	PPVT 2012 Z
Decile = 2	0.065	-0.005	0.347***	0.279**
	(0.100)	(0.075)	(0.082)	(0.095)
Decile = 3	0.160	0.023	0.334***	0.217
	(0.095)	(0.070)	(0.110)	(0.124)
Decile = 4	0.225**	0.066	0.200*	0.069
	(0.089)	(0.055)	(0.105)	(0.120)
Decile = 5	0.294**	0.028	0.490***	0.281**
	(0.111)	(0.066)	(0.103)	(0.124)
Decile = 6	0.386***	0.110**	0.556***	0.243**
	(0.083)	(0.044)	(0.058)	(0.086)
Decile = 7	0.401**	0.088	0.693***	0.384***
	(0.139)	(0.089)	(0.092)	(0.102)
Decile = 8	0.482***	0.159**	0.805***	0.384**
	(0.111)	(0.060)	(0.131)	(0.133)
Decile = 9	0.593***	0.125*	0.720***	0.221**
	(0.100)	(0.065)	(0.061)	(0.098)
Decile = 10	0.884***	0.229***	1.037***	0.420***
	(0.082)	(0.052)	(0.070)	(0.132)
Mother's Schooling		0.031***		0.027***
		(0.007)		(0.009)
Father's Schooling		0.021***		0.001
		(0.005)		(0.009)
Numeric WAIS		-0.006		-0.000
		(0.006)		(0.007)
Vocabulary WAIS		0.014**		0.010
		(0.006)		(0.008)
PPVT 2010 Z		0.321***		0.385***
		(0.016)		(0.022)
Height at Birth Z		0.008		0.016
		(0.016)		(0.023)
Weight at Birth Z		-0.020		-0.010
		(0.020)		(0.035)
Constant	1.261***	0.563	0.094	-0.810
	(0.338)	(0.484)	(0.848)	(0.708)
Observations	3,185	3,183	1,392	1,390
R-squared	0.105	0.227	0.139	0.291

*** p<0.01, ** p<0.05, * p<0.1

Standard errors clustered at a regional level

Table A3: CBCL Estimations, Deciles

	Longitudinal Estimation for children aged 39 to 71 months in 2012		Longitudinal Estimation for children aged 72 to 83 months in 2012	
VARIABLES	CBCL 2012 Z	CBCL 2012 Z	CBCL 2010 Z	CBCL 2010 Z
Decile = 2	-0.074	-0.028	0.016	0.074
	(0.045)	(0.042)	(0.103)	(0.079)
Decile = 3	-0.151**	-0.064	0.137	0.163*
	(0.070)	(0.077)	(0.126)	(0.091)
Decile = 4	-0.169**	-0.052	-0.149	-0.003
	(0.063)	(0.060)	(0.226)	(0.198)
Decile = 5	-0.220***	-0.015	-0.028	0.132
	(0.041)	(0.048)	(0.146)	(0.146)
Decile = 6	-0.248***	-0.019	-0.071	0.142
	(0.061)	(0.055)	(0.117)	(0.127)
Decile = 7	-0.283***	-0.036	-0.208	0.046
	(0.082)	(0.070)	(0.150)	(0.113)
Decile = 8	-0.381***	-0.093**	-0.349**	-0.030
	(0.030)	(0.040)	(0.148)	(0.154)
Decile = 9	-0.439***	-0.059	-0.285*	0.089
	(0.049)	(0.042)	(0.151)	(0.183)
Decile = 10	-0.652***	-0.114	-0.452***	0.025
	(0.032)	(0.066)	(0.099)	(0.133)
Mother's Schooling		-0.021***		-0.022**
		(0.006)		(0.010)
Father's Schooling		-0.006		-0.002
		(0.007)		(0.017)
Numeric WAIS		-0.003		0.011
		(0.003)		(0.010)
Vocabulary WAIS		-0.011***		-0.028**
		(0.004)		(0.010)
CBCL 2010 Z		0.379***		0.310***
		(0.019)		(0.032)
Height at Birth Z		-0.026		-0.006
		(0.019)		(0.023)
Weight at Birth Z		0.029**		0.006
		(0.012)		(0.034)
Constant	1.368**	1.953***	1.304*	2.168***
	(0.549)	(0.469)	(0.691)	(0.566)
Observations	5,660	5,658	1,396	1,395
R-squared	0.070	0.225	0.084	0.205

*** p<0.01, ** p<0.05, * p<0.1

Standard errors clustered at a regional level

Table A4: PPVT with HAZ and WFH as control variables.

	Longitudinal Estimation for Children aged 52 to 71 months in 2012		Longitudinal Estimations for Children aged 72 to 83 months in 2012	
VARIABLES	PPVT 2012 Z	PPVT 2012 Z	PPVT 2012 Z	PPVT 2012 Z
Quintile = 2	0.045	0.043	0.004	-0.001
	(0.051)	(0.051)	(0.080)	(0.080)
Quintile = 3	0.064	0.061	0.117*	0.108
	(0.041)	(0.040)	(0.065)	(0.066)
Quintile = 4	0.122**	0.119**	0.232***	0.218**
	(0.046)	(0.045)	(0.077)	(0.078)
Quintile = 5	0.167***	0.158***	0.152*	0.137*
	(0.042)	(0.041)	(0.076)	(0.078)
Mother's Schooling	0.032***	0.032***	0.029***	0.028***
	(0.007)	(0.007)	(0.008)	(0.008)
Father's Schooling	0.022***	0.022***	0.005	0.005
	(0.005)	(0.005)	(0.009)	(0.009)
Numeric WAIS	-0.005	-0.006	-0.001	-0.001
	(0.006)	(0.006)	(0.007)	(0.006)
Vocabulary WAIS	0.015**	0.014**	0.010	0.010
	(0.006)	(0.006)	(0.008)	(0.008)
PPVT 2010 Z	0.321***	0.320***	0.388***	0.383***
	(0.017)	(0.017)	(0.021)	(0.021)
Height at Birth Z	0.009	0.002	0.014	0.003
	(0.016)	(0.015)	(0.023)	(0.021)
Weight at Birth Z	-0.022	-0.021	-0.008	-0.014
	(0.020)	(0.021)	(0.035)	(0.036)
Child's Height 2010 (Z)		0.035**		0.051***
		(0.016)		(0.013)
Peso por Altura Z score		-0.018**		0.007
		(0.007)		(0.017)
Constant	0.547	0.560	-0.841	-0.849
	(0.495)	(0.500)	(0.672)	(0.658)
Observations	3,183	3,183	1,390	1,390
R-squared	0.226	0.227	0.283	0.286

*** p<0.01, ** p<0.05, * p<0.1

Standard errors clustered at a regional level

Table A5: CBCL with HAZ and WFH as control variables				
	Longitudinal Estimation for children aged 39 to 71 months in 2012		Longitudinal Estimation for children aged 72 to 83 months in 2012	
VARIABLES	CBCL 2012 Z	CBCL 2012 Z	CBCL 2010 Z	CBCL 2010 Z
Quintile = 2	-0.042	-0.041	0.048	0.042
	(0.058)	(0.058)	(0.106)	(0.103)
Quintile = 3	0.001	0.003	0.104	0.092
	(0.036)	(0.037)	(0.110)	(0.110)
Quintile = 4	-0.048	-0.046	-0.021	-0.039
	(0.047)	(0.049)	(0.106)	(0.106)
Quintile = 5	-0.064	-0.062	0.030	0.010
	(0.045)	(0.048)	(0.130)	(0.127)
Mother's Schooling	-0.021***	-0.021***	-0.022**	-0.024**
	(0.006)	(0.006)	(0.009)	(0.009)
Father's Schooling	-0.007	-0.007	-0.003	-0.002
	(0.007)	(0.007)	(0.017)	(0.017)
Numeric WAIS	-0.003	-0.003	0.011	0.010
	(0.003)	(0.003)	(0.010)	(0.009)
Vocabulary WAIS	-0.012***	-0.012***	-0.028**	-0.028**
	(0.004)	(0.004)	(0.010)	(0.010)
CBCL 2010 Z	0.379***	0.380***	0.314***	0.315***
	(0.019)	(0.019)	(0.032)	(0.032)
Height at Birth Z	-0.026	-0.025	-0.006	-0.019
	(0.019)	(0.021)	(0.022)	(0.023)
Weight at Birth Z	0.029**	0.032**	0.007	-0.001
	(0.012)	(0.012)	(0.033)	(0.034)
Child's Height 2010 (Z)		-0.006		0.060***
		(0.012)		(0.019)
Weight for Height 2010 (Z)		-0.014		0.010
		(0.011)		(0.026)
Constant	1.958***	1.982***	2.237***	2.222***
	(0.476)	(0.468)	(0.561)	(0.551)
Observations	5,658	5,658	1,395	1,395
R-squared	0.224	0.224	0.203	0.207

*** p<0.01, ** p<0.05, * p<0.1

Standard errors clustered at a regional level