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Inequality of Opportunities at Early Ages: Evidence from Chile

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ABSTRACT This paper examines inequality of opportunity for Chilean children starting from an early age. It uses a psychometric test designed to assess children's receptive vocabulary (PPVT), height, and weight as opportunity measures. We consider traditional circumstances such as parental income and educational level, but improve on the previous literature including mother's cognitive skills in our assessment. Our results indicate that Chilean children do not exhibit significant differences in height or weight either as newborns or at two to four years old. Nevertheless, there is evidence of inequality of opportunities for vocabulary skills. Maternal cognitive ability is the greatest contributor. Finally, the evidence also suggests that inequality of opportunity on vocabulary skills increases with age.

1. Introduction

There is a recent and growing literature that studies inequality of opportunity. The original approach developed by John Roemer has been translated into different methodologies that relate variables at the individual level, such as personal income or achievement in academic measurement tests, with his exogenous circumstances. These methodologies have been proposed by Bourguignon, Ferreira, and Walton (2007) and Checchi and Peragine (2010), and were later expanded on by Paes de Barros (2009) and Ferreira and Gignoux (2011). Several indicators have been constructed that calculate the level of inequality of opportunities for different countries, allowing comparisons over time and across countries. These studies have focused on examining the inequality on wages, educational performance, and access to basic services (drinking water, electricity, and sewage). However, the literature falls short when it comes to examining the inequality at early ages, especially for health outcomes and cognitive development.

This is particularly relevant when we consider the vast empirical evidence that suggests the importance of opportunities for young children. On one hand, health outcomes such as height and weight have been shown to be important predictors of outcomes in adolescence and adulthood (Grantham-McGregor et al., 2007). Also, cognitive ability measured at early ages is highly correlated with educational outcomes such as college attendance and returns to schooling (Heckman & Carneiro, 2003). Additionally, early interventions that seek to improve health outcomes or cognitive development have long-term results on variables such as schooling, employment, and wages (Maluccio et al., 2009; Hoddinott, Maluccio, Behrman, Flores, & Martorell, 2008; and Gertler et al., 2014). Consequently, it is critical to study the level and evolution of young children's opportunities.

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An Online Appendix is available for this article which can be accessed through the online version of this journal available at http://dx.doi.org/10.1080/00220388.2016.1262025

Previous evidence has found that Latin America has a high level of inequality of opportunities for adolescents, Ferreira and Gignoux (2014) perform a comparative study of students who took the Programme of International Student Assessment or PISA test, and they find that inequality seems to be higher in Latin American countries and parts of continental Europe. Related to the research on equality of opportunities, several papers have focused on estimating the relationship of the household's socio-economic status and child outcomes, also finding that Latin America tends to exhibit greater inequality. For instance, using data from Ethiopia, Peru, India, and Vietnam, López Bóo (2013) finds that from ages five to eight, the relevance of socio-economic background seems to decrease for cognitive skills, at the same time Peru stands out as a the country with the largest socio-economic gaps. Similarly, Schady et al. (2015) study the wealth gradient of children's cognitive skills in Chile, Colombia, Ecuador, Nicaragua, and Peru; they find that there are important gaps by wealth and that entering school does not seem to reduce the gaps. For Chile however, there is evidence of an improvement in equality of opportunities for young children. Contreras, Larranaga, Puentes, and Rau (2012) find that from 1990 to 2006, the equality of opportunities improved for children between zero and five years of age for the following variables: access to preschool, good nutrition and water, and sanitation. Nonetheless, our paper contributes with evidence regarding the inequality of opportunities for variables more closely related to the quality of the provision of health and educational services than simple access.

Following the methodology presented in Ferreira and Gignoux (2014), this paper contributes new evidence regarding the measurement of inequality of opportunity for three aspects. First, it shows evidence of the inequality of opportunities at an early age (two to four years old). Second, it examines the degree of inequality of opportunity using health and cognitive variables as opportunities. In the case of health, we use height and weight at birth and height and weight from two to four years old, and for cognitive variables we use a vocabulary test (the PPVT). Finally, we control for a number of factors traditionally ignored in the literature, which prove to be significant when it comes to explaining inequality. Specifically, mother's cognitive skills, measured through the Wechsler Adults Intelligence Scale (WAIS) test, are a key factor in inequality of opportunities.

The evidence suggests that in Chile, newborns do not have significant differences in height or weight regardless of socioeconomic background. In other words, anthropometric outcomes are the same for all children no matter their original socioeconomic background. However, there is evidence that inequality of opportunity represents 17 per cent of the inequality observed in children's cognitive test performance. This measurement of inequality rises significantly with age. Upon deconstructing this index of inequality of opportunity, maternal cognitive ability is the greatest contributor to inequality. Variables such as the presence of durable goods and parental education levels also have a significant impact.

This paper is divided into five sections. First is this introduction, Section 2 presents the data used in this paper. Section 3 describes the methodology used in the paper. Section 4 discusses the results, and Section 5 presents the conclusions.

2. Data

This study uses the first round of the 2010 Early Childhood Longitudinal Survey (ELPI for its acronym in Spanish). It includes data on 11,175 children born between 1 January 2006 and 31 August 2009. It consisted of questionnaires from two household visits. The first visit was a socio-demographic household survey. On the second visit, several instruments were used to assess the cognitive, social-emotional, and physical development of the child. The survey is nationally representative for households with children five years old and younger.

An important aspect of the survey is that it not only uses data about the circumstances typically used in inequality of opportunity literature such as household income, durable products in the home, ethnicity, and parental education, it also includes measures such as maternal cognitive ability through the use of the WAIS test.

We focus on three different outcomes: height, weight, and a vocabulary test. The survey provides information on birth and current height and weight. We restrict the sample to children between 30 to 60 months of age because the vocabulary test was only given to that sub-group.[1] The final sample consists of 6114 children.

2.1. Main outcomes: Peabody picture vocabulary test (PPVT), height, and weight

The PPVT is a psychometric test designed to assess children's receptive vocabulary; the international version has been translated into Spanish (Test de Vocabulario en Imágenes Peabody o TVIP). The instrument is given to children between 2.5 and 5 years old. The test contains 125 laminated sheets, each of which contains four pictures. The examiner says a word and then asks the child to identify the picture that best corresponds to the word.

The PPTV has been used for different goals such as proving the level of vocabulary accuracy at certain ages, estimating the child's scholastic aptitude, and longitudinal studies that measured changes in vocabulary accuracy over time. Importantly, the PPVT has predictive power over several relevant outcomes during childhood and adulthood, such as wages (Schady et al., 2015).

The standardised scores are scaled from 55 to 145 points. Less than 96 points is a low score, while scores between 96 and 103 points are average. Finally, scores above 103 are high scores (Dunn, Padilla, Lugo, & Dunn, 1986).

The survey also collects information about current and birth height and weight. In the case of current health outcomes, the enumerator measures the children, while the mother provides birth data.

A first approach to measure inequality of opportunity is to compare these indicators by income level. We present the results using the absolute measure of each opportunity in the left graph, and the standardised variable in the right. Figure 1 shows birth height of children in Chile by income quintile. On average, children born in 2009 are 49.6 centimetres tall. From the figure we observe that height is highly independent of socioeconomic background. A similar pattern is observed for birth weight in Figure 2. The children weighed 3368 grammes at birth on average. Again, there are very small socioeconomic differences in this outcome.[2] Thus, according to Figures 1 and 2, Chilean children have similar conditions at birth for anthropometric outcomes. This is quite a surprising result considering

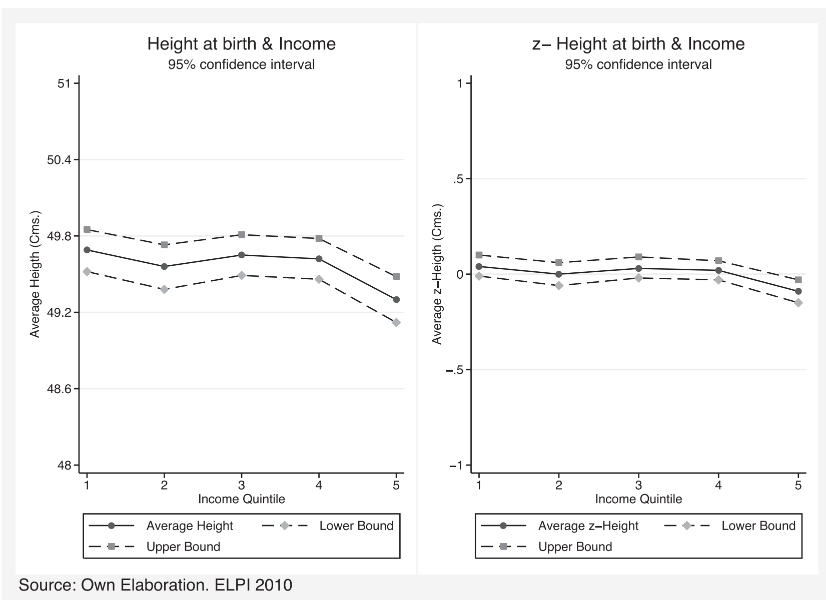

Figure 1. Average newborn height by income quintile.

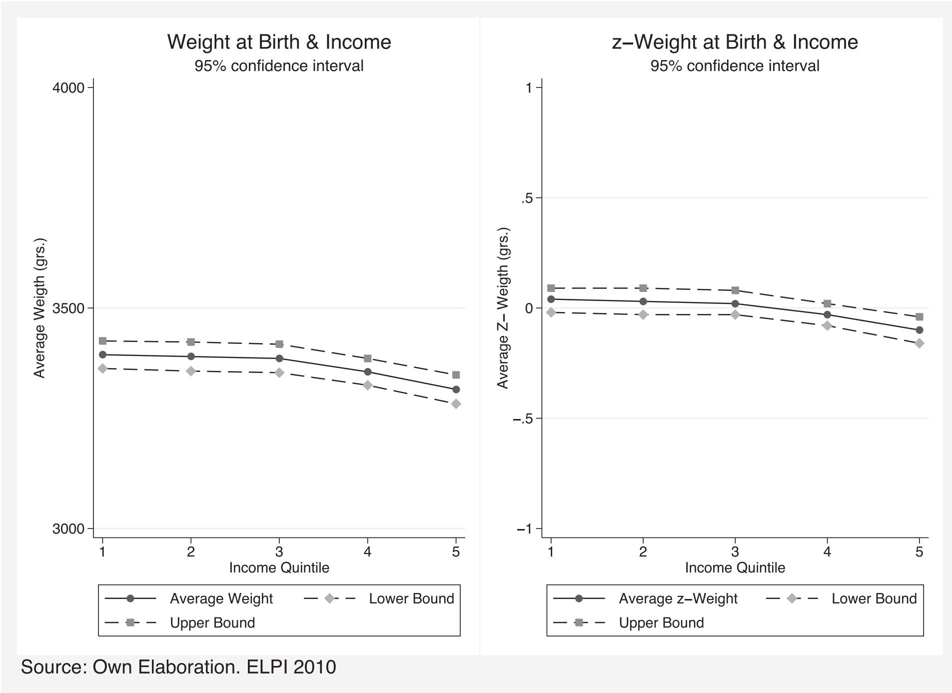

Figure 2. Average newborn weight by income quintile.

the high levels of income inequality in Chile. One plausible explanation for these results is the public health policies that started in the 1920s and were greatly expanded during the 1970s. In 1924 Chile started a programme to provide milk for the children of working mothers and in 1937 the passage of the 'Mother-Child Law' initiated a plan of public health policies aimed at reducing risk during pregnancy through periodic medical checks at community health centres.[3] These policies were accompanied with a food intervention that provided half a litre of milk for children. While these policies were ambitious, their coverage was low, reaching no more than 5 per cent of children by the 1940s. It was in 1970, after Salvador Allende was elected, that this programme increased its reach to almost 60 per cent of the children below 15 years of age and 54 per cent of pregnant women (Hakim & Solimano, 1976).[4] While there are no studies that provide a causal link between these policies and health outcomes, other studies have argued that past health policies (since 1940) are associated with improvements in health outcomes such as height (Nunez & Pérez, 2015). In addition, the Nunez and Pérez (2015) provide evidence indicating the gap in height between individuals from different socio-economic groups is decreasing over time, which is consistent with a positive effect of the nutritional policies. Nowadays, Chile exhibits some health outcomes that are comparable or better than other OECD nations, for instance the percentage of low birth weight in Chile is 6 per cent, lower than the 6.7 per cent average for OECD countries in 2011.[5]

In contrast, Figure 3 shows the PPVT and standardised PPVT by household income quintile. The figure shows that there is significant inequality in vocabulary development, for instance children from the richest families are 0.7 standard deviations above children from the poorest families.[6] In addition, as we show in Section 4, that gap increases with age. Using a different data set, we also found that similar differences are present for older children; at fourth grade the differences in test scores between the poorest and richest quintile is 0.8 in math scores and 0.7 in language ones, and by tenth grades the gap increases to 1.2 standard deviations in math and 0.9 in language.[7] These results suggest that the differences found in Ferreira and Gignoux (2014) at age 15 can be in part already explained by differences before age six.

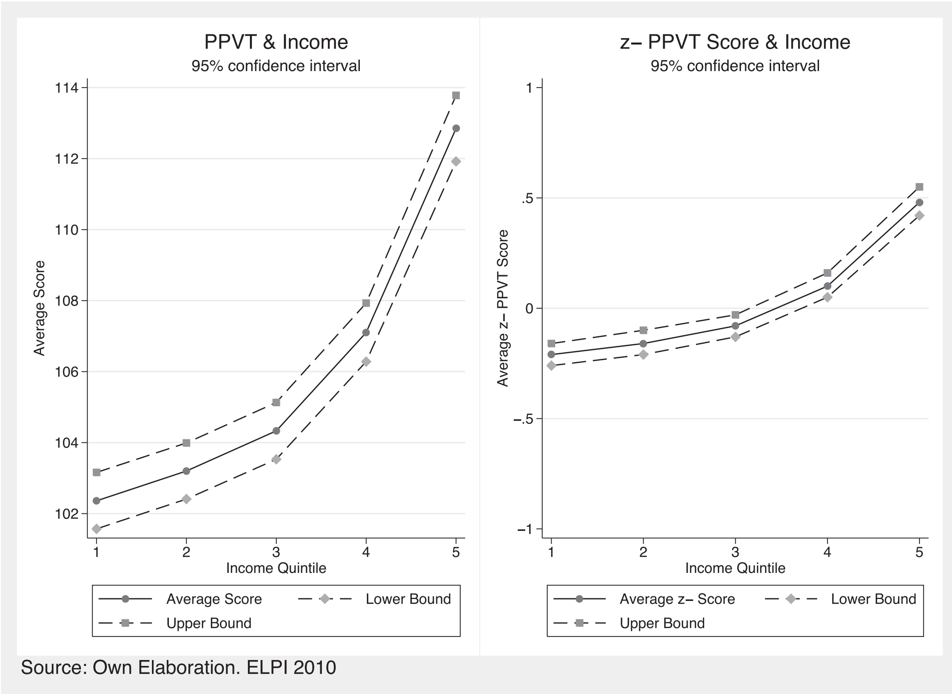

Figure 3. Vocabulary development by income quintile.

2.2. Circumstances: household characteristics

The ELPI allows us to construct several important variables that can be considered household circumstances. The previous literature mainly focuses on parents' education, per capita income, gender, ethnicity and household durables. We include all those variables, but more importantly we include maternal cognitive ability, which has not been included in the previous literature.

As the measure of cognitive skills we use the Wechsler Adults Intelligence Scale (WAIS). The WAIS is designed to measure global intelligence of individuals between 16 and 64 years old, regardless of education, socio-economic status, or reading level. It involves the application of two scales, vocabulary and numeracy, comparing the results to the average scores obtained by subjects of the same age. The WAIS has been shown to have high measurement quality and predictive capacity on the future behaviour of an individual; on the other hand, it needs to be updated approximately every 10 years to offset to so-called 'Flynn effect' – the increase in IQ over time seen in most countries.

The WAIS test was given to the mothers as two subtests. The first subtest is a digit span that assesses working memory, processing speed, and short-term auditory memory. A high score implies rapid adaptation to the stimuli demands and flexibility of cognitive adaptation. The second subtest is the vocabulary subtest that tests the ability to receive new information, store and use it properly. The test scale for each subset ranges from 0 to 19 points (Apfelbeck & Hermosilla, 2000).

As mentioned above we include parental education and occupation and per-capita income as circumstances. As a measure of wealth, we also include information about durable goods. We consider number of siblings as a measure of circumstances because it limits the available resources for any specific child in the household. Geographical zones help us to control for differences in the provision of public services. We also include whether the child is a member of an ethnic group as a measure of differentiated access to public services, labour markets, and general potential discrimination.

Table 1 shows the descriptive statistics for the entire sample and then by child age. We observe that 16 per cent of the sample have mothers with primary education, 57 per cent of mothers have a

Table 1. Sample statistics

	Whole Sample		2 Years		3 Years		4 Years	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
PPVT Score	106	15.19	104.3	11.54	106	16.06	108.2	16.97
Weight (Grammes)	16503	3621	14830	2678	16641	3571	18503	3803
Height (Centimeters)	98.81	6.60	93.34	5.13	99.49	5.49	104.70	4.97
Male = 1	0.50	0.50	0.50	0.50	0.50	0.50	0.49	0.50
Mother without formal education of unknown = 1	0.01	0.10	0.01	0.10	0.01	0.11	0.01	0.10
Mother with primary education = 1	0.16	0.37	0.15	0.35	0.16	0.37	0.18	0.38
Mother with secondary education = 1	0.57	0.50	0.57	0.50	0.57	0.50	0.55	0.50
Mother with vocational education = 1	0.13	0.33	0.13	0.33	0.13	0.34	0.12	0.33
Mother with college education = 1	0.14	0.34	0.15	0.36	0.13	0.33	0.14	0.35
Father without formal education of unknown = 1	0.07	0.26	0.07	0.25	0.08	0.27	0.08	0.27
Father with primary education = 1	0.15	0.36	0.14	0.35	0.16	0.37	0.16	0.37
Father with secondary education = 1	0.53	0.50	0.54	0.50	0.53	0.50	0.50	0.50
Father with vocational education = 1	0.10	0.30	0.10	0.30	0.11	0.31	0.08	0.28
Father with college education = 1	0.15	0.35	0.16	0.37	0.13	0.33	0.17	0.38
Father Self-Employed = = 1	0.11	0.31	0.10	0.30	0.10	0.31	0.13	0.33
Ethnicity = 1	0.08	0.27	0.07	0.26	0.08	0.27	0.07	0.26
Urban = 1	0.91	0.29	0.92	0.27	0.91	0.29	0.90	0.31
Per-Capita HH Income	1.16	1.53	1.24	1.70	1.14	1.55	1.11	1.21
Father Employment Unknown = 1	0.31	0.46	0.31	0.46	0.32	0.47	0.30	0.46
Refrigerator = 1	0.93	0.25	0.93	0.25	0.93	0.26	0.94	0.23
Washing machine = 1	0.78	0.42	0.78	0.42	0.77	0.42	0.80	0.40
Microwave = 1	0.55	0.50	0.56	0.50	0.55	0.50	0.56	0.50
Laptop = 1	0.23	0.42	0.22	0.42	0.23	0.42	0.25	0.43
TV cable = 1	0.46	0.50	0.45	0.50	0.47	0.50	0.46	0.50
Number of Siblings	0.99	1.00	0.93	1.00	0.99	1.00	1.08	0.99
Maternal WAIS score (numeracy)	6.97	2.94	7.05	2.90	6.91	2.90	6.99	3.10
Maternal WAIS score (vocabulary)	8.41	3.70	8.44	3.76	8.36	3.66	8.52	3.71
Number of Observations	6114		1700		3219		1195	

Notes: Per-capita household income in 100,000 s of 2010 Chilean peso. Average exchange rate during 2010 was 501 Chilean pesos per US dollar.
Source: ELPI 2010.

secondary education, and 14 per cent have a college education. Meanwhile 11 per cent of the fathers are self-employed, and 8 per cent of the children belong to an ethnic group. The average per-capita household income is $115,900 Chilean pesos, equivalent to US $200. Most of the households own a refrigerator (93%), but only 23 per cent own a laptop. There are no differences in circumstances by child age.

3. Methodology

This section closely follows Ferreira and Gignoux (2014), which presents and discusses the construction of inequality of opportunity indexes that are robust to standardisation of the outcome variables under study. They focus on the academic achievement of 15 year-olds using PISA test scores, which are standardised and compared across countries.

They extend the methodology proposed by Bourguignon et al. (2007) and Ferreira and Gignoux (2011). Additionally, they build on Roemer (2009), which states that observed results depend on two factors, the effort (E) of an individual, and his or her life circumstances (C) such as household income and parental education. Given that we are interested in inequality of opportunities at early ages, the effort component is much less important.[8] Thus, the test scores can be expressed as a function of circumstances and a random or chance factor (μ).

$$score = g(C, \mu) \tag{1}$$

Finally, assuming linearity, the observed result can be expressed as a linear relationship with the circumstances and a random factor:

$$score_i = C_i^{'}\theta + \epsilon_i \tag{2}$$

Ferreira and Gignoux (2014) show that several inequality indexes such as the Generalized Entropy and Gini coefficient are not equivalent before and after standardising the outcome variable, which leads them to use the variance, which is ordinally invariant to standardisation. Thus they propose the following index of inequality of opportunities:

$$D_{IOp} = \frac{Var(C_i^{'}\widehat{\theta})}{Var(score_i)} \tag{3}$$

Where $\hat{\theta}$ corresponds to the OLS estimators of Equation (2).

The use of the variance has several complications. It increases with the mean and does not hold the transfer sensibility axiom, however, it is additively decomposable. Moreover, the index proposed by Ferreira and Gignoux (2014) corresponds to an R-squared of the linear relationship between the outcome variable and the set of circumstances (Equation [2]).

Additionally, the linear approximation can be decomposed as follows:

$$\hat{\theta}_{IOp} = \sum_j \hat{\theta}^j = \sum_j (Var\ score)^{-1} \left[\hat{\theta}_j^2\ var\ C_j + 2\sum_k \hat{\theta}_k \hat{\theta}_j cov\left(C_k C_j\right) \right] con\ j \neq k \tag{4}$$

This decomposition allows us to calculate the contribution of each circumstance to total inequality; however as Ferreira and Gignoux (2014) point out, the decomposition is sensible to the specification of Equation (2) and the number of circumstances included.

In the general specification there could be some omission of relevant variables, then the contribution of each circumstance would be contaminated by the correlation between the omitted variable and the circumstance. In the Online Appendix we add maternal health variables as a set of circumstances. Our results are robust to the inclusion of these variables.[9]

In terms of the mechanisms that could explain how family characteristics and parental ability affect children behaviour, Duncan, Kalil, Mayer, Tepper, and Payne (2005) propose several ways that could explain the positive correlations between parents and children's traits that have been largely found in the literature. They state and test four mechanisms for the transmission of traits: genetic, socio-economic status, role-models, and parenting style. In the case of the genetic mechanism, abilities and other traits are simply inherited. The socio-economic mechanism basically states that parents with higher abilities tend to have a higher income, and are then able to provide more and better inputs for their children's ability production function. Good parenting styles such as involvement, control, emotional warmth, and cognitive stimulation could also have a positive effect on many children's outcomes including ability, and more able parents could in general be more likely to adopt these good parenting styles. Finally, the role-model mechanism assumes that children mimic the behaviour of their parents; it is more likely to explain the transmission of social behaviour than cognitive skills. The authors find some evidence in favour of the genetic and role model mechanisms for several behavioural and cognitive traits.

4. Results

In this section we present the results from several models of Equation (2). First, we evaluate the importance of including the maternal WAIS test in calculating the effects of inequality of opportunity on a child's vocabulary development. At the same time, we compare this inequality with birth height and weight in Table 2. A second set of calculations is done for different age groups, which examine whether inequality of

Table 2. OLS estimation, whole sample

VARIABLES	PPVT	PPVT	Weight at birth	Height at birth
Male = 1	−0.065**	−0.067***	0.137***	0.202***
	(0.026)	(0.025)	(0.026)	(0.027)
Mother without formal education of unknown = 1	0.069	0.102	−0.027	−0.097
	(0.123)	(0.126)	(0.121)	(0.114)
Mother with primary education = 1	−0.155***	−0.022	0.045	0.043
	(0.036)	(0.036)	(0.041)	(0.043)
Mother with vocational education = 1	0.152***	0.078*	−0.065	−0.004
	(0.048)	(0.047)	(0.042)	(0.048)
Mother with college education = 1	0.345***	0.214***	−0.073	−0.069
	(0.053)	(0.052)	(0.051)	(0.054)
Father without formal education of unknown = 1	−0.046	−0.040	−0.121**	−0.087
	(0.052)	(0.050)	(0.055)	(0.054)
Father with primary education = 1	−0.185***	−0.165***	0.003	−0.012
	(0.036)	(0.035)	(0.040)	(0.040)
Father with vocational education = 1	0.115**	0.103**	−0.049	−0.035
	(0.051)	(0.048)	(0.048)	(0.048)
Father with college education = 1	0.076	0.023	0.012	0.041
	(0.052)	(0.051)	(0.048)	(0.053)
Father Self-Employed = = 1	0.047	0.040	0.026	0.044
	(0.043)	(0.042)	(0.046)	(0.044)
Ethnicity = 1	−0.158***	−0.120***	0.054	−0.003
	(0.042)	(0.041)	(0.047)	(0.052)
Urban = 1	0.126***	0.109***	−0.004	−0.015
	(0.040)	(0.039)	(0.045)	(0.044)
Per-Capita HH Income	0.021	0.012	−0.015	−0.022*
	(0.014)	(0.012)	(0.012)	(0.012)
Father Employment Unknown = 1	−0.112***	−0.106***	−0.066**	−0.021
	(0.030)	(0.029)	(0.031)	(0.031)
Refrigerator = 1	0.096**	0.086*	−0.044	0.044
	(0.047)	(0.046)	(0.054)	(0.053)
Washing machine = 1	0.069**	0.031	0.071**	0.032
	(0.031)	(0.031)	(0.035)	(0.035)
Microwave = 1	0.081***	0.066**	−0.054*	−0.028
	(0.027)	(0.027)	(0.028)	(0.028)
Laptop = 1	0.126***	0.095**	−0.085**	−0.046
	(0.042)	(0.041)	(0.038)	(0.044)
TV cable = 1	0.224***	0.216***	0.012	0.032
	(0.027)	(0.027)	(0.028)	(0.029)
Number of Siblings	−0.080***	−0.088***	0.048***	0.023
	(0.014)	(0.013)	(0.014)	(0.015)
Maternal WAIS subset numeracy		0.036***	−0.001	0.005
		(0.005)	(0.005)	(0.005)
Maternal WAIS subset vocabulary		0.040***	−0.000	−0.000
		(0.004)	(0.004)	(0.004)
Constant	−0.310***	−0.803***	−0.029	−0.154*
	(0.065)	(0.072)	(0.082)	(0.084)
Observations	6,114	6,114	6,114	6,114
R-squared	0.139	0.173	0.019	0.016

Notes: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

opportunity increases over time. We calculate these changes for vocabulary development and child's height and weight from two to four years old. These results are presented in Tables 3–5. To statistically evaluate the differences among the inequality of opportunity, we calculate confidence intervals for the R-squared. We calculate bootstrap confidence intervals using 999 repetitions and adjusting for bootstrap bias (adjusted

Table 3. OLS estimations, Two year-old

VARIABLES	PPVT	Weight (Grammes)	Height (Cms)
Male = 1	−0.016	0.129***	0.169***
	(0.038)	(0.035)	(0.039)
Mother without formal education of unknown = 1	−0.089	−0.209	−0.390
	(0.131)	(0.260)	(0.292)
Mother with primary education = 1	−0.043	0.089	−0.031
	(0.049)	(0.055)	(0.066)
Mother with vocational education = 1	0.049	0.020	−0.006
	(0.071)	(0.053)	(0.059)
Mother with college education = 1	0.239***	0.052	0.076
	(0.081)	(0.058)	(0.072)
Father without formal education of unknown = 1	−0.039	−0.034	0.076
	(0.071)	(0.083)	(0.093)
Father with primary education = 1	−0.004	0.015	0.065
	(0.051)	(0.055)	(0.058)
Father with vocational education = 1	0.194***	−0.069	0.013
	(0.072)	(0.066)	(0.074)
Father with college education = 1	0.010	−0.069	0.120
	(0.077)	(0.060)	(0.074)
Father Self-Employed = = 1	0.080	−0.055	−0.011
	(0.071)	(0.061)	(0.064)
Ethnicity = 1	−0.005	−0.014	−0.065
	(0.060)	(0.053)	(0.078)
Urban = 1	0.069	0.144*	−0.063
	(0.055)	(0.077)	(0.066)
Per-Capita HH Income	0.005	0.001	−0.004
	(0.015)	(0.012)	(0.016)
Father Employment Unknown = 1	−0.103**	−0.001	−0.009
	(0.041)	(0.042)	(0.046)
Refrigerator = 1	0.045	−0.066	0.017
	(0.066)	(0.077)	(0.084)
Washing machine = 1	0.050	0.127***	0.009
	(0.044)	(0.049)	(0.053)
Microwave = 1	0.024	−0.014	0.059
	(0.040)	(0.039)	(0.042)
Laptop = 1	0.034	−0.074*	−0.040
	(0.060)	(0.042)	(0.059)
TV cable = 1	0.097**	−0.005	0.083**
	(0.038)	(0.037)	(0.041)
Number of Siblings	−0.097***	−0.025	−0.022
	(0.018)	(0.018)	(0.020)
Maternal WAIS subset numeracy	0.030***	−0.001	−0.016*
	(0.008)	(0.007)	(0.008)
Maternal WAIS subset vocabulary	0.015***	0.004	0.006
	(0.006)	(0.005)	(0.007)
Constant	−0.570***	−0.656***	−0.877***
	(0.100)	(0.113)	(0.118)
Observations	1,700	1,700	1700
R-squared	0.127	0.022	0.031

Notes: Robust standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.

Table 4. OLS estimations three year-old

VARIABLES	PPVT	Weight (Grammes)	Height (Cms.)
Male = 1	−0.060	0.137***	0.211***
	(0.036)	(0.034)	(0.030)
Mother without formal education of unknown = 1	−0.010	−0.130	−0.151
	(0.183)	(0.141)	(0.154)
Mother with primary education = 1	−0.075	−0.022	0.035
	(0.051)	(0.053)	(0.044)
Mother with vocational education = 1	0.134**	0.135**	0.122**
	(0.065)	(0.064)	(0.050)
Mother with college education = 1	0.213***	−0.064	0.028
	(0.075)	(0.066)	(0.058)
Father without formal education of unknown = 1	−0.035	0.063	0.092
	(0.073)	(0.062)	(0.061)
Father with primary education = 1	−0.190***	0.047	0.016
	(0.051)	(0.050)	(0.045)
Father with vocational education = 1	0.038	−0.136**	−0.056
	(0.069)	(0.066)	(0.053)
Father with college education = 1	0.053	0.028	0.042
	(0.074)	(0.063)	(0.054)
Father Self-Employed = = 1	0.015	0.060	−0.027
	(0.061)	(0.055)	(0.046)
Ethnicity = 1	−0.138**	−0.043	−0.029
	(0.057)	(0.071)	(0.049)
Urban = 1	0.115**	0.059	−0.064
	(0.057)	(0.062)	(0.052)
Per-Capita HH Income	0.018	0.001	0.008
	(0.018)	(0.008)	(0.012)
Father Employment Unknown = 1	−0.087**	−0.042	0.016
	(0.043)	(0.042)	(0.035)
Refrigerator = 1	0.081	0.012	0.019
	(0.067)	(0.067)	(0.057)
Washing machine = 1	−0.049	0.057	0.108***
	(0.044)	(0.043)	(0.041)
Microwave = 1	0.083**	−0.003	−0.008
	(0.038)	(0.038)	(0.033)
Laptop = 1	0.086	−0.004	−0.025
	(0.058)	(0.047)	(0.045)
TV cable = 1	0.258***	0.032	0.015
	(0.039)	(0.037)	(0.033)
Number of Siblings	−0.086***	−0.057***	−0.033**
	(0.019)	(0.017)	(0.016)
Maternal WAIS subset numeracy	0.037***	0.008	0.011**
	(0.007)	(0.006)	(0.006)
Maternal WAIS subset vocabulary	0.048***	0.007	0.010*
	(0.006)	(0.005)	(0.005)
Constant	−0.830***	−0.204**	−0.213**
	(0.103)	(0.098)	(0.095)
Observations	3,219	3,219	3,219
R-squared	0.184	0.017	0.034

Notes: Robust standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.

column) and not adjusting for bias (unadjusted column). The confidence intervals of the overall indexes, from Table 2, are presented in Table 6, while the confidence intervals of the indexes calculated by age, from Tables 3–5, are shown in Table 7. Finally, in Table 8 we calculate the contribution of each circumstance to overall inequality of opportunities.

Table 5. OLS estimations four year-old

VARIABLES	PPVT	Current Weight	Current Height
Male = 1	−0.113*	0.114*	0.128***
	(0.060)	(0.060)	(0.047)
Mother without formal education of unknown = 1	0.665**	0.640**	0.133
	(0.306)	(0.290)	(0.243)
Mother with primary education = 1	0.112	0.057	−0.110
	(0.090)	(0.087)	(0.076)
Mother with vocational education = 1	−0.005	−0.048	−0.044
	(0.102)	(0.100)	(0.080)
Mother with college education = 1	0.200*	−0.056	0.051
	(0.115)	(0.121)	(0.085)
Father without formal education of unknown = 1	−0.110	−0.080	0.010
	(0.118)	(0.119)	(0.088)
Father with primary education = 1	−0.269***	−0.096	0.020
	(0.088)	(0.095)	(0.067)
Father with vocational education = 1	0.134	0.025	0.045
	(0.112)	(0.109)	(0.080)
Father with college education = 1	0.004	−0.091	0.008
	(0.105)	(0.113)	(0.080)
Father Self-Employed = = 1	0.031	0.011	0.033
	(0.095)	(0.098)	(0.072)
Ethnicity = 1	−0.195*	0.070	−0.064
	(0.115)	(0.100)	(0.079)
Urban = 1	0.165*	0.247**	−0.065
	(0.092)	(0.109)	(0.062)
Per-Capita HH Income	0.073*	0.006	−0.021
	(0.042)	(0.024)	(0.024)
Father Employment Unknown = 1	−0.113	0.121	0.107**
	(0.072)	(0.074)	(0.054)
Refrigerator = 1	0.148	0.167	0.220**
	(0.124)	(0.121)	(0.105)
Washing machine = 1	0.226***	−0.076	0.046
	(0.081)	(0.079)	(0.060)
Microwave = 1	0.057	−0.037	−0.048
	(0.065)	(0.063)	(0.050)
Laptop = 1	0.096	0.078	0.126**
	(0.085)	(0.080)	(0.064)
TV cable = 1	0.243***	0.014	0.114**
	(0.063)	(0.066)	(0.052)
Number of Siblings	−0.076**	−0.055*	−0.008
	(0.032)	(0.030)	(0.026)
Maternal WAIS subset numeracy	0.038***	0.004	0.002
	(0.011)	(0.011)	(0.008)
Maternal WAIS subset vocabulary	0.054***	0.005	−0.002
	(0.010)	(0.009)	(0.007)
Constant	−1.104***	0.136	0.610***
	(0.185)	(0.187)	(0.134)
Observations	1,195	1,195	1,195
R-squared	0.255	0.025	0.039

Notes: Robust standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.

As circumstance variables we include: parental education and occupation, per-capita household income, ethnicity, geographical zone, dummy variables for durable goods, number of siblings, and the maternal numeracy and vocabulary WAIS scores separately.

In Table 2 we observe that inequality of opportunity in vocabulary development is 17 per cent for the entire population (when WAIS scores are included), while the inequality of opportunity index for

Table 6. PPVT inequality index, 95 per cent confidence intervals calculated using bootstrap (999 repetitions)

	Not Including WAIS	
	Unadjusted	Adjusted
	PPVT	PPVT
LB	0.125	0.122
UP	0.159	0.152

	Including WAIS					
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
	PPVT		Height at Birth		Weight at Birth	
LB	0.160	0.156	0.013	0.009	0.016	0.013
UP	0.193	0.188	0.026	0.019	0.030	0.022

Notes: LB: lower bound. UP: upper bound. Unadjusted: Confidence interval by percentile methodology. Adjusted: bootstrap bias corrected confidence interval.

Table 7. 95 per cent confidence intervals calculated using bootstrap, by age (999 repetitions)

	2 years old		3 years old		4 years old	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
PPTV						
LB	0.107	0.091	0.167	0.158	0.225	0.197
UP	0.171	0.146	0.213	0.204	0.311	0.284
Weight						
LB	0.019	0.013	0.014	0.011	0.023	0.014
UP	0.056	0.025	0.034	0.020	0.068	0.027
Height						
LB	0.028	0.023	0.028	0.021	0.036	0.021
UP	0.067	0.036	0.055	0.041	0.081	0.042

Notes: LB: lower bound. UP: upper bound. Unadjusted: Confidence interval by percentile methodology. Adjusted: bootstrap bias corrected confidence interval.

birth height and weight is close to 2 per cent. These results confirm the evidence presented in Section 2 where we see little difference in height and weight at birth by income quintile, but significant differences in vocabulary development by income. Additionally, we observe in Table 2 that inequality of opportunity increases when we consider maternal cognitive measures from 14 per cent to 17 per cent when maternal cognition is included in the model. Table 6 shows the confidence intervals calculated by using bootstrapping for these indexes, which statistically confirms the higher degree of inequality in vocabulary development than in birth measurements. The comparison between the confidence intervals for child vocabulary development including maternal cognitive measures is statistically significant at 5 per cent when we use bootstrap methodology that corrects for bias (adjusted column) and when we do not correct for bias (unadjusted column). Thus, we find that including maternal cognitive skills increases the index of inequality of opportunities in 20 per cent. This is an important lesson, because it implies that to understand the degree of inequality of opportunities for child outcomes, we should include parental characteristics that measure cognitive ability.

Table 8. Contribution of each circumstance to inequality of opportunities in PPVT

	Whole Sample	2 years old	3 years old	4 years old
Male = 1	.001	0	.0009	.003
Mother without formal education of unknown = 1	−.0001	.0005	0	.0031
Mother with primary education = 1	.0015	.003	.0052	−.0071
Mother with vocational education = 1	.0027	.0016	.0056	−.0001
Mother with college education = 1	.0165	.0251	.0142	.0172
Father without formal education of unknown = 1	.0005	.0008	.0003	.0016
Father with primary education = 1	.0106	.0002	.0126	.0203
Father with vocational education = 1	.0032	.0085	.0012	.0028
Father with college education = 1	.0015	.0008	.003	.0003
Father Self-Employed = = 1	−.0001	.0006	−.0001	−.0001
Ethnicity = 1	.0026	.0001	.0034	.0045
Urban = 1	.0031	.0019	.0029	.0067
Per-Capita HH Income	.0035	.0017	.005	.0226
Missing Father Self-Employed = 1	.0028	.0037	.0015	.0048
Refrigerator = 1	.0023	.0012	.002	.0044
Washing machine = 1	.0021	.0037	−.0027	.0211
Microwave = 1	.0059	.0021	.0072	.0055
Laptop = 1	.0087	.003	.0075	.0098
TV cable = 1	.0242	.01	.0281	.0305
Number of Siblings	.0091	.0163	.0089	.006
Maternal WAIS subset numeracy	.0273	.026	.0253	.0322
Maternal WAIS subset vocabulary	.0445	.0163	.0524	.0656

Tables 3, 4, and 5 show the estimation results for children at ages two, three, and four years old respectively. We calculate the inequality index for vocabulary development and current height and weight including the WAIS test in all calculations. Note that the inequality index increases with age for vocabulary development, but remains relatively stable for weight and height. The inequality of opportunity index for cognitive development of the child increases from 0.125 at age two, to 0.186 at age three, and 0.255 at age four. That is, the index doubles from two years old to four.

Table 7 shows the confidence intervals calculated using bootstrapping. We can observe a significant increase in inequality of opportunities in vocabulary development from two to four years old. For instance, the adjusted confidence interval for age two is [0.09;0.15], while for age three is [0.16;0.20], and for age four is [0.20;0.28]. Then, the level of inequality of opportunities at age four is clearly higher than at two and three; a similar result can be found using the unadjusted confidence interval. Following López Bóo (2013) we further study if this finding can be explained by measurement error by estimating a non-parametric function between the PPVT score and child age for children in the poorest and richest quintile of the income distribution.[10] Figure 4 shows these functions, and we find that the skills gaps appear early in life and increase with age, and while there is more noise at ages over 51 months, this is due to a smaller sample size as shown in Table 8 of the Online Appendix.

The age trend could be in part explained by self-productivity of cognitive skills, as pointed out by Cunha and Heckman (2008) past levels of cognitive skills have a positive effect on current levels of cognitive skills; this implies that early gaps in cognitive skills tend by themselves to reproduce over time. This result is particularly important for public policy because it indicates that earlier interventions could be more efficient in reducing inequality of opportunities.

For the case of height and weight, Table 7 shows that there is no pattern with age. Moreover, all differences across ages are not significant. This result suggests that in terms of these anthropometric measures Chile has achieved an important level of equality.

Finally, Table 8 shows the contribution of each circumstance to inequality of opportunity. As mentioned by Ferreira and Gignoux (2011, 2014), omitted variables in Equation (2) make this decomposition less reliable than a calculation of a global index of inequality of opportunity.[11] Table 8 suggests that the most important factor is the maternal cognitive level as measured through

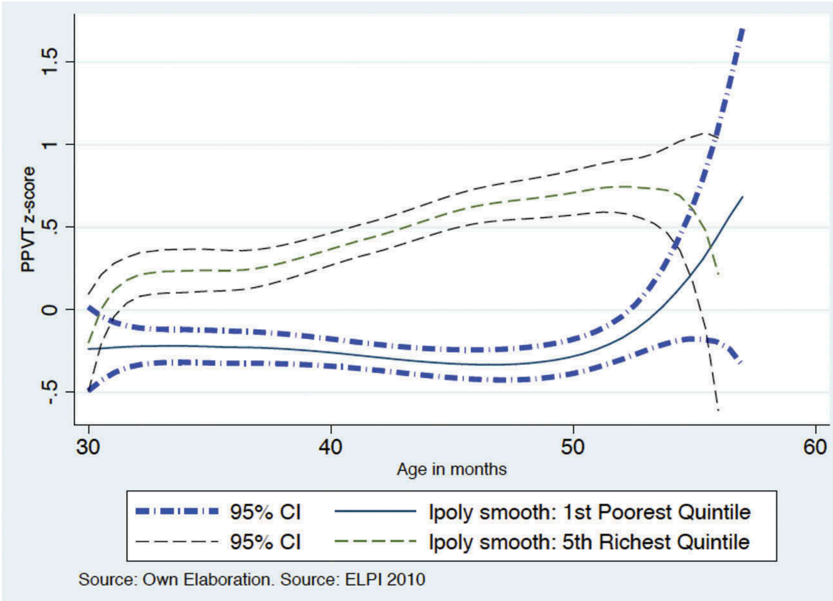

Figure 4. Age Patterns in PPVT, Local polynomial smooth estimator.
Note: Nonparametric estimation of standardised PPVT on age by household per capita income. Bandwidth is chosen to minimise the conditional weighted mean integrated squared error. For the poorest quintile bandwidth is 1.7 and for the richest quintile is 2.1

the WAIS test, with the vocabulary subset being more important. This can be explained because the PPVT also measures vocabulary skills, then there could be a direct transmission of vocabulary form mother to child. The importance of both components of the WAIS test also tends to increase with the age of the child. Additionally, household income also becomes more important as the child ages. This result suggests that the effects of income inequality could start early in life with a strong intergenerational transmission of income, which has been documented in Urzua, Rodriguez, and Contreras (2014).

5. Conclusions

In this paper we analyse inequality of opportunities for young children. Using a unique dataset from Chile, we take advantage of several measures of children's physical and cognitive development to assess the importance of circumstances. We also use detailed measures of maternal ability, which allows us to obtain a better approximation of the level of inequality of opportunities.

We find that for the sample, traditional circumstances such as household income and parental education explain 14 per cent of the variation in development of children between two and four years old. This increases to 17 per cent when considering maternal cognitive ability measures. These results suggest that inequality of opportunity that begins early in life is affected by maternal cognitive ability. Meanwhile, physical measures such as height and weight are much less likely to be affected inequality of opportunities.

Additionally, we found that inequality of vocabulary development increases significantly from age two to four, indicating that not only is inequality important at an early age, but also becomes increasingly important over time. Moreover, our results show similar gaps by income quintile in fourth grade testing, suggesting that socio-economic gaps in school could start before formal education.

In terms of policies that could be implemented to reduce the inequality of opportunities in skills, our results indicate that maternal ability plays an important role. Public policies should not necessarily focus on improving maternal skills, but might be more efficient to provide all mothers, and especially those from more disadvantaged backgrounds, with tools to help them stimulate their children. Some interventions in this vein have proved successful. For example, Attanasio, Fitzsimons, Grantham-McGregor, Douglas, and Rubo-Codina (2014) compared three interventions for children between 12 to 24 months in Colombia. The first intervention consisted of psychosocial stimulation, the second consisted of increasing nutrient quality and the third was a combination of the first and second. The authors find that only the first intervention had a positive and large effect on cognitive scores. Importantly, the stimulation programme was delivered through the local community and at a low cost, which could easily be replicated in other countries.

Also, free or cheap access to day-care centres could be useful to reduce skill gaps, although the evidence of this is mixed. Specifically, Noboa and Urzua (2012) find for Chile that public day-care centres can at the same time improve child outcomes such as emotional regulation, but negatively affect others such as child-adult interactions. Thus it is important to consider not only coverage but also quality of day-care policies.

Since research has found the importance of both cognitive and non-cognitive abilities in adulthood (Heckman, Stixrud, & Urzua, 2006), future research should focus on non-cognitive abilities. This could be done in two ways: one is considering parental non-cognitive abilities as child circumstances, and the other is studying how circumstances affect children's non-cognitive abilities.

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Notes

1. We group children into three age categories: two, three, and four years of age, which correspond to children between 25 to 30 months-old, between 36 to 47 months-old, and between 48 to 59 months-old respectively.
2. All means are not statistically different at 5 per cent, except for the means of children living in the richest households, who have a slight lower height and weight than the rest of the population.
3. The minister of Health at the time, Eduardo Cruz Coke, was one of the most influential people promoting these policies (Hakim & Solimano, 1976).
4 For more details on those policies see Larrañaga (2010).
5. OECD Family database: http://www.oecd.org/social/family/database.htm, accessed on 22 September 2015.
6. The differences are statistically significant at 5 per cent.
7. See Online Appendix, Table 10 A
8. In the standard approach to measure inequality of opportunities (previously developed by Bourguignon et al. (2007) and Ferreira and Gignoux (2011) both circumstances and effort play a role in explaining inequality of opportunities. In that

model a person's effort depending on the circumstances and a random factor or luck (ν) is expressed as $E = h(C, v)$. In the present context, it is difficult to argue that effort plays a role for very young children. As a consequence of that we follow a model based only on circumstances.

9. We excluded some variables because of a potential double causality problem such as maternal socio-emotional status, whether the mother was working and parenting techniques. If these variables are positively related to maternal cognitive skills, we would be over-estimating the effect of mother's skills or any other variable included in our specification
10. As mentioned before, we perform a robust analysis including more variables and the results are very similar. See Tables 1A to 7A in the Online Appendix.
11. As mentioned before, we perform a robust analysis including more variables and the results are very similar. See Tables 1A to 7A in the Online Appendix

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