Birth Order and Human Capital Development

Evidence from Ecuador

Monique De Haan
Erik Plug
José Rosero

ABSTRACT

In this paper we examine the effect of birth order on human capital development in Ecuador. Using family fixed effects models we find positive and persistent birth order effects; earlier-born children stay behind in their human capital development from infancy to adolescence. Turning to potential mechanisms, we find that earlier-born children receive less quality time from their mothers. Additionally, they are breastfed shorter. Poverty plays a key role in explaining these birth order patterns; we observe the largest birth order effects in poor and low-educated families, accompanied with reversed birth order effects in rich and high-educated families.

I. Introduction

In this paper we investigate birth order effects on human capital development of children in Ecuador. Specifically, we estimate the effect of birth order on preschool cognition, secondary school enrollment and child labor, using regression

Corresponding author: Erik Plug. Email: e.j.s.plug@uva.nl. Address: Roetersstraat 11, 1018 WB Amsterdam, The Netherlands.

Erik Plug works at the University of Amsterdam and is affiliated with TIER, Tinbergen Institute, IZA and UCLS. Monique De Haan works at the University of Oslo and is affiliated with CESifo and Jose Rosero works at Instituto Nacional de Estadística y Censos in Quito-Ecuador. *The authors thank three anonymous referees, as well as seminar and conference participants in Amsterdam, Bern, Trondheim and Quito for their comments and suggestions. In this article, they make use of two data sources: the Ecuadorian System of Selection of Beneficiaries (SELBEN) and the Ecuadorian Study of Early Childhood Development Programs (ENEVIN). The SELBEN is owned by the Ecuadorian government and is not freely available. The data can be obtained by asking permission to use the data at the Ecuadorian government. The ENEVIN is collected by the authors and can be obtained beginning October 2014 through September 2017 from Erik Plug, Roetersstraat 11, 1018 WB Amsterdam, The Netherlands, e.j.s.plug@uva.nl. The data are only available for the purpose of replicating the results presented in this article and not for answering new research questions.*

[Submitted July 2012; accepted April 2013]

ISSN 0022-166X E-ISSN 1548-8004

models that include family fixed effects to rule out that estimated birth order patterns are driven by differences in family size or in any other omitted family characteristic that is shared among siblings. In addition, we explore possible pathways that predict the birth order patterns we observe. In particular, we look for differences in maternal treatment and test whether the amount of time mothers allocate to various types of childcare depends on birth order.

We have at our disposal two data sources. The data we use to examine the effect of birth order on child schooling and child labor are taken from the SELBEN database that covers almost all poor families in Ecuador surveyed at some point in time during 2001 and 2006. The data we use to examine the effect of birth order on preschool cognition come from a recent survey we organized ourselves in Ecuador between 2008 and 2010 among a sample of poor families with children eligible for early child development programs. Cognitive test scores were taken from children up to 6 years old. Of relevance to our study, mothers were asked questions about, among others, the amount of time spent with each child on a particular day during particular activities.

In this paper we find that child schooling increases with birth order while child labor decreases with birth order. Similar birth order patterns are also observed much earlier in life; we find positive effects of birth order on various measures of preschool cognition. When we consider the time mothers spend with their children as possible driver behind these birth order patterns, we find that later-born children receive more childcare time than earlier-born children. In particular, later-born children receive much more cognitive childcare time (which includes playing, drawing, talking, and reading stories or books). They are also breastfed longer. Our findings are consistent with models where time investment in children early in life is important for the further development of human capital (Cunha et al. 2006; Almond and Currie 2011).

Since the birth order results we find are opposite to what is commonly found in the Western world (Björklund and Salvanes 2011), we tentatively conclude that the negative relationship between birth order and human capital may not hold in the context of a developing country. We do not provide any causal evidence on why this is but speculate about related explanations that are more common to developing countries: high poverty rates, low levels of parental education, and high teenage pregnancy rates. When we consider preschool cognition, we do not find much. But when we consider school and work outcomes of children in their teens, we find the largest birth order effects in poor and low-educated families. In fact, birth order effects turn slightly negative for teenage children growing up in richer families, having higher educated parents. Poverty (or the absence thereof) seems therefore a likely driver behind the birth order divide between developing and developed countries.

The paper continues as follows. Section II provides some empirical and theoretical background on the relationship between birth order, cognitive development, and child schooling. Section III shortly describes Ecuador and the data we have collected there. After introducing the empirical fixed effects strategy in Section IV, Section V presents our main birth order estimates for child cognition, child schooling and child labor. In Section VI we investigate potential explanations for our positive birth order estimates and finally Section VII presents conclusions.

II. Background and Related Literature

Birth order is a recurrent theme in social science. One of the first empirical references we found on this topic is Francis Galton's book English Men of Science, which was published in 1874 (Galton 1874). In there, Galton collected information on the birth order of some hundred successful scientists, observed many firstborns among them, and tentatively concluded that birth order is important, with children of higher birth order doing worse. Since then, numerous researchers have examined how birth order influences a child's cognitive development and educational attainment. We will first summarize findings from recent birth order studies in developed and developing countries before we turn to the contributions of this study.

A. Birth order studies in developed countries

One of the most influential and recent birth order studies is Black, Devereux, and Salvanes (2005), which aims to identify the effect of birth order on educational attainment by estimating a family fixed effects model using large administrative samples on all Norwegians who were 16–74 years old somewhere between 1986 and 2000. Similar to the original Galton study, Black, Devereux, and Salvanes find that later-born children do significantly worse in school. Since then, many researchers have examined comparable birth order relationships using similar family fixed effects techniques with large (and often administrative) samples. Most of these birth order studies confirm that higher birth order hinders cognitive development and reduces educational attainment (Conley and Glauber 2006; Gary-Bobo, Picard, and Pietro 2006; Kantarevic and Mechoulan 2006; Kristensen and Bjerkedal 2007; Booth and Kee 2009; Black, Devereux, and Salvanes 2005; De Haan 2010).

There are several theories about the economic, psychological and biological causes of negative birth order effects (see Blake 1989). These theories typically relate changes in childhood conditions to changes in child cognition and schooling. We discuss three such theories, with different sources of childhood variation. First, childhood conditions may vary with family resources (including time and financial resources). If early child investments are important (Cunha et al. 2006; Almond and Currie 2011), we expect negative birth order effects because earlier-born children do not share the family resources with younger siblings, at least not for some time. Second, childhood conditions may depend on the child's intellectual environment. If family intellectual environment can be proxied by the average age of parents and children within a family (Zajonc 1976), we should find a negative birth order effect because later-born children are born into a less favorable family intellectual environment than their earlier-born siblings. And thirdly, differences in childhood conditions may have biological or prenatal origins.[1]

1. Later-born children, for example, may face higher prenatal environmental risks because of increased levels of maternal antibody. If maternal antibody attacks the development of their fetal brain (Gualtiery and Hicks, 1985), we expect negative birth order effects. In addition, children born to older parents may also have a weaker genetic makeup if egg and sperm quality decline with parental age (Kidd, Eskenazi, and Wyrobek 2001).

Although these theories predict negative birth order effects, hardly any empirical work tests these theories separately. What complicates matters, as Black, Devereux, and Salvanes (2005) argue, is the difficulty to distinguish between different theories without additional information. There are a few exceptions. Price (2008) investigates whether children of different birth order are treated differently in terms of the time parents spent with them. With data taken from the American Time Use Survey, he observes that first-born children receive significantly more quality time from their parents than second-born children of the same age from a similar family. With data taken from the PSID, Monfardini and See (2012) replicate previous birth order findings and observe that earlier-born children receive more maternal quality time than later-born children. Monfardini and See also find some evidence that the negative relationship between child test scores and birth order is not affected once they take the effect of maternal quality time into account.[2]

De Haan (2010) tackles a related question, asks whether parents treat earlier-born children differently than later-born children but looks at financial resources instead of time resources. With information taken from the Wisconsin Longitudinal Study on whether children received any money from their parents, she shows that children of different birth order are indeed raised differently with parents spending significantly less money on later-born children. All these findings are consistent with a resource dilution story or a modified version thereof; that is, earlier-born children do better in school because they receive a larger share of parental resources in terms of time, money, or both.

B. Birth order studies in developing countries

While there is ample evidence in developed countries that children of higher birth order tend to do worse in many dimensions, we know fairly little about the effects of birth order on child schooling in developing countries. Interestingly, the few convincing empirical studies that are around find a reversed pattern; that is, children of higher birth order stay in school longer and participate less in child labor.

Ejrnaes and Pörtner (2004), for example, apply family fixed effect estimation to identify the effect of birth order on educational attainment using longitudinal data from the Laguna area in the Philippines. They find that children with older siblings generally do better than children with younger siblings. They also find some evidence that the estimated birth order patterns for completed years of schooling are more pronounced in low-educated families. These birth order findings, they argue, are consistent with an optimal stopping rule where families stop having children when the last child has favorable endowments.[3]

2. One should, however, be careful in interpreting these birth order results. If the time mothers spent with their children is an outcome variable that depends on birth order, maternal quality time is not the appropriate variable to include in regressions that aim to identify the effect of birth order on child test scores. Angrist and Pischke (2008) call this a bad control problem and warn us that controlling for such outcome variables is misguided.

3. Birth order patterns observed in developed countries are said to be consistent with an alternative stopping rule where families stop having children when the last child has unfavorable endowments (see also Black, Devereux, and Salvanes 2005).

Edmonds (2006) applies the same family fixed effect models but concentrates on the relationship between birth order and child labor using children between 6 and 15 years old in Nepal. He finds that most boys but, in particular, girls with younger siblings tend to work more, which he attributes to older siblings having comparative advantages over their younger siblings in market and household production. Also, Dammert (2010) applies the same fixed effect strategy using measures of both school attendance and child labor, now to a sample of children who are 7–14 years old in Nicaragua and Guatemala, finding the strongest birth order effects on child labor. With measures for the amount and type of child labor, she finds that boys with younger siblings spend more time in market work, whereas girls with younger siblings spend more time in domestic work. The birth order effects for school attendance are not significantly different from zero.[4]

Tenikue and Verheyden (2010) use data for children aged between six and 18 years from 12 African countries. They use the number of completed years of schooling at the time of the survey as their educational attainment measure and confirm that children with younger siblings receive less education in poor families. In addition, they interact birth order with a household wealth index and report that the positive birth order effects observed in poor families turn negative in rich families.[5] In explaining these birth order findings, they rely on Basu and Van (1998) who argue that financial constraints and lack of resources may drive parents to send their children out to work. If the earnings of earlier-born children contribute to family resources that allow later-born children to further develop their human capital and to go to school, positive birth order effects on child schooling and negative birth order effects on child labor should be found in poor, low-educated families.

Just as there are theories that predict negative birth order effects, there are explanatory theories that predict a positive relationship between birth order and child development; among these are fertility models based on optimal stopping rules, comparative advantages among siblings, and lack of financial resources. While these theories seem more appropriate to explain birth order effects in the developing world, little work is done in testing these empirically.

C. Our contributions

Two messages emerge from the causal birth order literature. The first message is that birth order effects are systematically different in developed and developing countries. The second message is that there is little empirical work done on what is causing these birth order effects, let alone work on what is causing the birth order divide between developed and developing countries.

In this study we have set ourselves the goal to better understand why this is and explore the effect of birth order on human capital development in the context of a devel-

4. Emerson and Souza (2008) find comparable birth order results using Brazilian data but without controlling for family fixed effects.

5. We should note that Tenikue and Verheyden (2010) do not estimate fully interacted models; only the dummy variable indicating whether a child is a first-born is interacted with household wealth. If, for example, the relation between age and education differs with household wealth the estimated interaction effects might pick up these differential age effects.

oping country. Apart from estimating the effect of birth order on child schooling and, relatedly, child labor in Ecuador for the very first time, our study contributes to the birth order literature in three important ways. First, we examine to what extent birth order affects child cognition, measured when children are in their preschool years. If birth order effects are persistent, we expect to see that birth order effects observed in infancy and early childhood carry over into later childhood and adolescence. Second, we follow Price (2008) and examine to what extent birth order affects the time mothers invest in her children. In contrast to Price, however, we need to explain a birth order effect in the opposite direction; that is, we should find that mothers invest more (and not less) time in later-born children than in earlier-born children. The relationship between birth order, early child cognition, and time investments have not been studied previously, at least not in the context of a developing country. And third, we examine to what extent birth order effects vary with three important characteristics of developing countries; poverty, low-educated parents and teenage motherhood. These results may shed some light on the birth order divide between developing and developed countries.

III. Context and Data

Ecuador is a lower-middle income country with 13 million inhabitants. Poverty and inequality are considered to be great concerns. In 2006, around 38 percent of the Ecuadorian population was considered poor as their per capita consumption was below the national poverty line. The income distribution is highly unequal: While the bottom 40 percent of the population accounts for 15 percent of national consumption, the richest 20 percent accounts for about half of national consumption (SIISE 2010). In Ecuador the fertility rate is about 3.3 births per woman and 26 percent of the mothers are below the age of 19 at first birth.

Children in Ecuador start school at age 6 and education is compulsory until age 14. Primary education consists of six years followed by six years of secondary education, of which the first three years are compulsory. In primary education almost all children are enrolled in school. In secondary education enrollment rates are much lower with a sharp drop at the transition from compulsory to noncompulsory education.

Consistent with other developing countries, child labor is common in Ecuador; in 2009, 11.3 percent of all children between 12 and 18 years old worked instead of going to school. Child labor is even more prominent among children above the compulsory schooling age; about 17.1 percent of children between 15 and 18 years old participate in the labor market instead of attending classes at school (Ecuadorian Labor Survey 2009).[6]

The data used in the empirical analysis come from two different sources. We use data from the Ecuadorian System of Selection of Beneficiaries (SELBEN) to investigate the relationship between birth order and child outcomes observed when children are between 12 and 18 years old. We use self-collected data from the Ecuadorian Study of Early Childhood Development Programs (ENEVIN) to examine the relation-

6. These figures exclude children that both work and go to school.

ship between birth order and early childhood outcomes, not contained in SELBEN, when children are in their preschool years. These two data sets are comparable in important dimensions and described in more detail below.

A. SELBEN

SELBEN contains survey information on socioeconomic background, labor supply, school enrollment, family relations, and demographic characteristics of all family members living in geographical areas previously selected by a poverty map. It covers around 90 percent of the rural and urban areas with a high incidence of poverty. The survey information is used to determine the eligibility of families for several government programs aimed at helping the poor. Survey data are collected at some point in time between 2001 and 2006. The survey asks mothers to report on, among others, the number of children she gave birth to. For each residing child in the family information is collected about year of birth and the family relationship with the head of the family (which is in most cases the father).[7] These pieces of information are used to construct our birth order measure.

The sample we start with consists of all children from families with at least two children of secondary school age. This sample contains information on 677,247 children from 287,216 families and allows us to estimate family fixed effect models. In addition, we exclude all families with more than four children to be consistent with the sample restrictions we make for the early childhood outcomes.

We compute birth order on the basis of the age of the observed children of the head of the household. We make the following sample restrictions to compute what we consider the most accurate birth order measure. Firstly, we limit the sample to families in which all children of the mother are alive. Secondly, we restrict the sample to families in which the number of own-birth children of the mother coincides with the observed number of children of the head of the household. And finally, we drop all families with multiple births because of the ambiguity in assigning birth order in these families. These restrictions together reduce the sample to 160,112 children living in 73,225 families.

We investigate the effect of birth order on secondary school enrollment and child labor. A child is considered to be enrolled in secondary education if he or she is between 12 and 18 years old and the parent reports that the child was enrolled in school and attended school on a regular basis in the year of the survey. Because secondary education is compulsory until age 14, we also investigate the effect of birth order on postcompulsory enrollment for children between 15 and 18 years old. In our sample, about 86 percent of the children between 12 and 14 is actually enrolled. The percentage of children between 15 and 18 years old that is enrolled in school is lower and equals 70 percent. Child labor is a dummy variable that equals 1 if the child's main economic activity in the past week was work outside the house. We investigate the effect of birth order on child labor for children who are 12–18 years old as well as for children who are 15–18 years old, for whom schooling is no longer compulsory. Table 1 provides some descriptive statistics.

7. Information about children who moved out of their parents' home is not collected.

Table 1
Descriptive Statistics

	SELBEN						ENEVIN		
	12–18 years			15–18 years			0–6 years		
	Mean	Standard Deviation	Within Family Standard Deviation	Mean	Standard Deviation	Within Family Standard Deviation	Mean	Standard Deviation	Within Family Standard Deviation
Outcome variables									
Enrollment	0.779	0.415	0.241	0.704	0.457	0.187			
Child labor	0.110	0.312	0.201	0.170	0.376	0.166			
Gross motor skills							0.141	0.981	0.798
Fine motor skills							0.138	0.996	0.802
Language skills							0.162	0.990	0.795
Social skills							0.152	0.976	0.803
Total preschool cognition							0.165	0.979	0.798
Child characteristics									
First-born	0.394	0.489	0.458	0.603	0.489	0.331	0.279	0.449	0.393
Second-born	0.448	0.497	0.488	0.317	0.465	0.363	0.386	0.487	0.460
Third-born	0.136	0.343	0.286	0.073	0.260	0.183	0.246	0.430	0.376
Fourth-born	0.021	0.143	0.113	0.007	0.086	0.063	0.089	0.285	0.226
Gender (1 if female)	0.472	0.499	0.371	0.458	0.498	0.265	0.488	0.500	0.379

Age (years)	14.657	1.904	1.452	16.291	1.095	0.702			
Age (months)							49.177	26.434	21.955
Age at test (months)							40.179	18.586	15.330
Time use (min per day) & breastfeeding (months)									
Total time							303.920	148.952	68.219
Quality time							185.244	91.485	41.087
Cognitive care							52.017	61.324	34.207
Other care							133.227	68.787	27.917
Breastfeeding							12.327	6.571	4.270
Number of observations	160,112			80,343			3,250		
Family characteristics									
Poverty index (0–1)	0.399	0.129		0.404	0.130		0.446	0.112	
Family belongs to richest 50%	0.203	0.402		0.216	0.412		0.303	0.460	
Schooling household head	7.612	3.967		7.651	4.010		7.728	3.672	
Head ≥ compulsory schooling	0.270	0.444		0.274	0.446		0.298	0.458	
Age mother	37.602	4.433		38.260	4.229		27.093	4.980	
Age mother at first birth	21.126	3.937		21.118	3.883		19.846	4.368	
Mother was teen at first birth	0.374	0.484		0.369	0.482		0.542	0.498	
Number of children in family	3.202	0.712		3.212	0.709		2.765	0.766	
Number of families	73,225			57,977			1,434		

B. ENEVIN

The data that we use to estimate the effect of birth order on preschool cognition comes from a survey designed to evaluate the impact of early childhood development programs in Ecuador (ENEVIN). In 2008, we collected survey data for a sample of poor families with children in their preschool years eligible for an early educational intervention. In the survey all children younger than 6 years old were exposed to a comprehensive battery of tests to measure their cognitive, motor, and social development. In 2010 we went into the field again and revisited the same families to collect additional data. In the second survey all children younger than 5 were tested, but mothers were also asked to keep a time diary. In this diary she reported the time spent on various activities as well as the presence of up to four children during each of these activities. We will use this information to investigate how mother's time investment varies with birth order.

Cognitive development is assessed using a child's score on the Nelson Ortiz test (Ortiz 1999). The Nelson Ortiz is a validated test that measures four dimensions of child development: language skills, gross motor skills, fine motor skills, and social behavior. The Nelson Ortiz test is suitable for children younger than 6 and is the official instrument used by Ecuadorian authorities to monitor the development of children. To generate the test scores, the administrator presents each child with a series of tasks and tests, observes the child's responses and behaviors, and then adds up the total number of successfully executed tasks and tests along four dimensions (language, gross motor, fine motor and social behavior). A total score of the child's development is also calculated by summing the scores in each dimension. The language and fine motor test scores are most informative about the child's cognitive skills, while the test scores measuring gross motor skills and social behavior are more related to the child's physical and social development. In our analysis we present all test scores that have been standardized with mean zero and standard deviation one in the full sample.

We mainly use test score information we collected in the second survey. If test score information is not available, however, we take the test score information from the first survey for those children who were younger than 6 in 2008. In our regression analysis, we always control for survey round and include dummies for age of the child when taking the test (measured in months).

The data set contains test score information for 5,262 children living in 2,228 families with at least two children for whom we observe test score information. As we already argued, we need families with at least two children for our family fixed effects models. In addition, we exclude all families with more than four children for two reasons: (i) time use data is available for at most four children per family; and (ii) the data contains too few families with more than four children.

As in SELBEN, we derive birth order from the age of the children observed in the survey. We select the sample in such a way to obtain the most accurate birth order measure; that is, we select those families in which all children of the mother are still alive, drop all families with multiple births and exclude families in which the number of children that live at home at the moment of the second survey is smaller than the number of children the mother gave birth to (which is measured in the first survey). The sample we end up with contains 3,250 children living in 1,434 families. Table 1 shows summary statistics for the ENEVIN sample.

IV. Empirical Model

Estimating the effect of birth order on child outcomes is complicated due to the correlation of birth order with family size. Because family size, and all (unobserved) family characteristics that are correlated with family size, can have an independent effect on child outcomes, a naive regression of child outcomes on birth order will likely give inconsistent estimates. We deal with this endogeneity problem by including family fixed effects. More specifically, the birth order model we estimate is specified as

$$(1)\quad y_{if} = \alpha + \beta_2 \cdot second_{if} + \beta_3 \cdot third_{if} + \beta_4 \cdot fourth_{if} + \lambda_f + X'_{if}\pi + \varepsilon_{if}$$

where y_{if} is the outcome of child i in family f, λ_f are family fixed effects and X_{if} include dummies for age and gender of the child. Because we use data on multiple children within a family, standard errors are clustered at the family level to correct for arbitrary within-family correlation.

The family fixed effects λ_f absorb all (un)observed characteristics that are constant within a family, including family size, and the estimated coefficients on the dummies $second_{if}$, $third_{if}$ and $fourth_{if}$ can therefore be interpreted as the effect of having order 2, 3, or 4 compared to being a first born. A common problem with estimating birth order effects using within-family variation is that the correlation between birth order and age of the child is amplified. We deal with this by including dummies for child's age in all regressions.

V. Results

A. Birth order effects on school enrollment and child labor

Table 2 presents the estimated effects of birth order on secondary school enrollment and labor participation of children between 12 and 18 years old. For each outcome, the table reports estimates for two different model specifications. The first specification, labeled as OLS, includes dummies for age and gender of the child as well as a full set of dummies for the number of children in the family. In estimating birth order effects the main concern is the high correlation of birth order with family size (and other family characteristics related with family size). Including family size as control variable is a first step in addressing this identification problem, but a more convincing specification, labeled as FE, is based on Equation 1, which includes family fixed effects.

The first column in Table 2 shows the OLS results and reveals a clear pattern; we find a significant positive association between birth order and secondary school enrollment. Relative to a base enrollment rate of 0.72 for the first-born child, the size of the birth order effects is large. Column 1 also shows the estimated coefficients on the family size dummies. In contrast to the birth order results, these estimates are all negative and show that the probability that a child is enrolled in school is lower for children born in larger families. This negative association between school enrollment and family size is consistent with previous findings in the economic literature (Black, Devereux and Salvanes 2005; De Haan 2010). We can however not give a causal interpretation to the estimated coefficients due to the fact that family size is likely correlated with (un)observed family characteristics.

Table 2
The Effect of Birth Order on Secondary School Enrollment and Child Labor

	Secondary School Enrollment (12–18)		Postcompulsory (15–18)		Child Labor (12–18)		Child Labor (15–18)	
	OLS	FE	OLS	FE	OLS	FE	OLS	FE
Second	0.013***	0.008**	0.021***	0.028***	–0.014***	–0.022***	–0.019***	–0.020***
	(0.002)	(0.003)	(0.003)	(0.008)	(0.002)	(0.003)	(0.003)	(0.008)
Third	0.051***	0.041***	0.064***	0.071***	–0.040***	–0.062***	–0.062***	–0.050***
	(0.004)	(0.006)	(0.006)	(0.017)	(0.003)	(0.005)	(0.005)	(0.015)
Fourth	0.105***	0.081***	0.126***	0.140***	–0.068***	–0.094***	–0.098***	–0.079***
	(0.007)	(0.011)	(0.017)	(0.032)	(0.004)	(0.009)	(0.012)	(0.028)
Family size								
Three	–0.039***		–0.044***		0.027***		0.041***	
	(0.003)		(0.005)		(0.002)		(0.004)	
Four	–0.127***		–0.146***		0.081***		0.116***	
	(0.004)		(0.005)		(0.002)		(0.004)	
N	160,112	160,112	80,343	80,343	160,112	160,112	80,343	80,343

Notes: All regressions include dummies for age (in years) and gender of the child. Secondary school enrollment is a dummy which equals 1 if the child was enrolled in school and attended school on a regular basis in the year of the survey. Child labor is a dummy variable that equals 1 if the child's main economic activity in the past week was work outside the house. Average enrollment for a first-born child is 0.72 and average child labor for a first-born child is 0.18. Standard errors (between parentheses) are clustered at the family level; ***significant at 1 percent, **significant at 5 percent, *significant at 10 percent.

Column 2 presents the results that include family fixed effects. These results show a similar birth order pattern as the results without family fixed effects. Relative to the first child, children of higher birth order are more likely to be enrolled in secondary school. These positive birth order patterns stand in sharp contrast to the negative birth order patterns found in Western countries but are consistent with the results found in other developing countries (Ejrnaes and Pörtner 2004; Emerson and Souza 2008; Tenikue and Verheyden 2010; Dammert 2010).

As we already mentioned, a potential explanation for the positive effect of birth order on secondary school enrollment is that the oldest children drop out of school because they have to work in order to contribute to family income. Columns 3 and 4 of Table 2 show the effect of birth order on labor participation for children between 12 and 18 years old. These results show, indeed, that first-born children are significantly more likely to work compared to their later-born siblings. The size of the estimated birth order effects become somewhat larger in absolute value when we include family fixed effects and show that a first-born child is almost 10 percent more likely to work than his or her fourth born sibling.

Table 2 also shows results for a sample of children who are above the compulsory schooling age (15–18 years old). Columns 3 and 4 present the results for school enrollment and show the same positive pattern observed for the full sample of adolescents. Moreover, the estimated birth order effects are somewhat amplified as expected when schooling is no longer compulsory. Columns 7 and 8 present the results for labor participation and show a decrease in the probability of working as birth order increases. The size of the estimated birth order effects is similar to the effects obtained in the full sample of adolescents.

B. Birth order effects on preschool cognition

Table 2 shows that first-born children are significantly less likely to be enrolled in secondary education compared to their later-born siblings. To investigate whether this positive birth order pattern is already observed early in life, we next investigate the effect of birth order on preschool cognition. Table 3 presents estimates of birth order effects on five dimensions of preschool cognition: gross motor skills, fine motor skills, language skills, social skills, and the sum of these four skill measures, using a sample of children younger than 72 months from ENEVIN. As in the previous table, results are shown using a specification that includes family-size dummies as well as a specification that relies on within-family variation for the identification of birth order effects.

The OLS results are shown in the first, third, fifth, seventh, and ninth columns, and are consistent with the findings presented for secondary school enrollment. Relative to the first child, later-born children perform significantly better on the different cognitive tests. The birth order differentials we observe appear most pronounced for the language and fine motor skill test scores.

Fixed effect estimates are presented in the second, fourth, sixth, eighth, and tenth columns. The estimated birth order effects are somewhat smaller in absolute value than the OLS estimates but, except for the result on social skills, the positive pattern between birth order and cognition is not sensitive to the inclusion of family fixed effects. In addition, the birth order effects remain most predictive for the language and fine motor skill tests scores. The estimated effects are nontrivial: We find that a

Table 3
The Effect of Birth Order on Preschool Cognition

	Gross Motor Skills		Fine Motor Skills		Language Skills		Social Skills		Total Preschool Cognition	
	OLS	FE	OLS	FE	OLS	FE	OLS	FE	OLS	FE
Second	0.034**	0.021	0.045***	0.039*	0.071***	0.046*	0.027**	–0.001	0.044***	0.026*
	(0.013)	(0.020)	(0.017)	(0.023)	(0.019)	(0.025)	(0.013)	(0.020)	(0.011)	(0.016)
Third	0.073***	0.046	0.094***	0.081**	0.134***	0.078*	0.039***	–0.019	0.085***	0.045
	(0.019)	(0.034)	(0.026)	(0.039)	(0.029)	(0.045)	(0.021)	(0.035)	(0.018)	(0.028)
Fourth	0.123***	(0.083*	0.141***	0.121**	0.210***	0.121*	0.077***	–0.003	0.138***	0.079*
	(0.029)	(0.050)	(0.039)	(0.061)	(0.045)	(0.068)	(0.032)	(0.054)	(0.027)	(0.042)
Family size										
Three	–0.047***		–0.062***		–0.090***		–0.042***		–0.060***	
	(0.014)		(0.017)		(0.020)		(0.014)		(0.012)	
Four	–0.070***		–0.121***		–0.167***		–0.078***		–0.109***	
	(0.020)		(0.029)		(0.033)		(0.022)		(0.020)	
N	3,250	3,250	3,250	3,250	3,250	3,250	3,250	3,250	3,250	3,250

Notes: All outcome variables are standardized test scores with mean zero and standard deviation one in the full sample. All regressions include dummies for the gender and age of the child at the moment of the test (in months), in addition we include a dummy which equals 1 if we use test score information collected in the first survey wave. Standard errors (between parentheses) are clustered at the family level; ***significant at 1 percent, **significant at 5 percent, *significant at 10 percent.

fourth-born child has a performance that is about 10 percent of a standard deviation higher than that obtained by a first-born sibling on the tests for language, fine motor, gross motor skills, and the composite measure of cognitive skills.

In sum, we find that later-born children have significantly higher human capital outcomes both in early childhood and in adolescence. Although the results for secondary school enrollment and preschool cognition are obtained using different data sets we believe that these findings can be interpreted as birth order effects being persistent because the given data sets are comparable on important dimensions. As shown in Table 1 in both the SELBEN and ENEVIN poor, low-educated families are overrepresented and family structure is very similar.

C. Estimating birth order effects by family size and gender

In this section we focus on two possible sources of heterogeneity in birth order effects: differences between families of different size and differences by gender.

We first explore how birth order effects vary by family size. Table 4 presents fixed effects estimates separately for families with two, three, and four children. The birth order estimates are comparable to those obtained on the full samples. We find positive birth order effects for school enrollment, negative birth order effects for child labor, and also (most) preschool cognition outcomes remain consistently higher for later-born siblings, regardless of the family size. But the birth order estimates are also different for different family sizes. In case of school enrollment and child labor, we find that the estimated birth order effects are larger in larger families. A potential explanation for this is that larger families are also poorer families. If it is the older sibling in poorer and larger families who works and contributes to family income, making it possible for later-born siblings to go to school, we would expect larger positive birth order effects in poorer and larger families.[8]

In case of preschool cognition, however, we do not find much. While the birth order estimates in families with three children for language and fine motor skills appear somewhat stronger, most birth order estimates by family size are too imprecise to be informative. This is why we rather work with the full sample and estimate birth order effects for preschool cognition averaged over different family sizes, as we do in our main analysis.

We next investigate how differences in birth order effects vary by gender, which is a more complicated heterogeneity test than the previous one for family size. If we were to estimate the effect of birth order separately for a sample of boys and girls, we would identify the birth order effects on families with at least two boys or two girls (due to the family fixed effect controls). This means that we cannot separate heterogeneity due to gender of the child from heterogeneity due to gender composition of the family. Instead we compare birth order effects for families with first-born sons relative to those for families with first-born daughters. This is a relevant margin if parents show strong preferences for sons; a favorable treatment for sons should give us stronger birth order effects among families with first-born daughters.

Table 5 presents fixed effect birth order estimates on separate samples split by gender of the first child. We find that the estimated birth order effects on school enrollment

8. We will investigate this poverty mechanism in more detail in Section VI.C.

Table 4
The Effect of Birth Order on Human Capital Outcomes, Fixed Effects by Family Size

	Enrollment		Child Labor		Preschool Cognition				
	12–18	15–18	12–18	15–18	Gross	Fine	Language	Social	Total
Two-child families									
Second	–0.008	0.033	–0.001	0.006	0.012	0.009	0.024	0.045	0.024
	(0.008)	(0.024)	(0.006)	(0.020)	(0.032)	(0.037)	(0.044)	(0.032)	(0.025)
N	25,282	12,480	25,282	12,480	1,258	1,258	1,258	1,258	1,258
Three-child families									
Second	0.009*	0.009	–0.022***	–0.010	0.049	0.061*	0.078**	–0.031	0.038
	(0.005)	(0.012)	(0.004)	(0.011)	(0.036)	(0.034)	(0.036)	(0.034)	(0.026)
Third	0.029***	0.037	–0.049***	–0.027	0.098	0.099*	0.149**	–0.047	0.073
	(0.009)	(0.026)	(0.008)	(0.022)	(0.062)	(0.059)	(0.066)	(0.062)	(0.046)
N	71,195	35,942	71,195	35,942	1,257	1,257	1,257	1,257	1,257

Four-child families

Second	0.011*	0.045***	–0.025***	–0.037***	0.022	0.162*	0.114	–0.003	0.072
	(0.005)	(0.013)	(0.005)	(0.012)	(0.053)	(0.088)	(0.088)	(0.050)	(0.050)
Third	0.042***	0.105***	–0.050***	–0.072***	–0.000	0.133	0.087	–0.069	0.034
	(0.010)	(0.026)	(0.009)	(0.024)	(0.062)	(0.087)	(0.102)	(0.062)	(0.055)
Fourth	0.065***	0.198***	–0.053***	–0.104***	0.023	0.183	0.125	–0.061	0.064
	(0.017)	(0.043)	(0.014)	(0.038)	(0.084)	(0.116)	(0.130)	(0.101)	(0.076)
N	63,635	31,921	63,635	31,921	735	735	735	735	735

Notes: Regressions for enrollment and child labor include dummies for age in years and gender of the child. Gross motor skills, fine motor skills, language skills, and social skills are standardized test scores with mean zero and standard deviation one in the full sample. All regressions using test scores as outcome variable include dummies for the gender and age of the child at the moment of the test (in months), in addition we include a dummy which equals 1 if we use test score information collected in the first survey wave. Preschool cognition corresponds to the sum of the scores in the four tests and is standardized to have mean zero and standard deviation one in the full sample. Standard errors (between parentheses) are clustered at the family level; ***significant at 1 percent, **significant at 5 percent, *significant at 10 percent.

Table 5
The Effect of Birth Order on Human Capital Outcomes, Fixed Effect Estimates by Gender of the First-Born

	Enrollment		Child Labor		Preschool Cognition				
	12–18	15–18	12–18	15–18	Gross	Fine	Language	Social	Total
First-born is a girl									
Second	0.002	0.014	0.011***	0.019*	0.026	0.031	–0.016	–0.013	0.006
	(0.005)	(0.013)	(0.004)	(0.011)	(0.033)	(0.040)	(0.041)	(0.032)	(0.025)
Third	0.033***	0.057**	–0.022***	–0.008	0.041	0.051	–0.033	–0.048	0.001
	(0.010)	(0.027)	(0.007)	(0.022)	(0.056)	(0.067)	(0.073)	(0.054)	(0.045)
Fourth	0.068***	0.145***	–0.062***	–0.072*	0.072	0.155	–0.005	0.041	0.065
	(0.017)	(0.051)	(0.013)	(0.042)	(0.080)	(0.102)	(0.109)	(0.085)	(0.066)
N	72,100	35,257	72,100	35,257	1,573	1,573	1,573	1,573	1,573
First-born is a boy									
Second	0.012**	0.028**	–0.043***	–0.034***	0.030	0.044	0.087**	0.007	0.042*
	(0.005)	(0.012)	(0.004)	(0.011)	(0.024)	(0.033)	(0.036)	(0.028)	(0.021)
Third	0.046***	0.070***	–0.089***	–0.064***	0.063	0.094*	0.163***	0.010	0.082**
	(0.009)	(0.023)	(0.008)	(0.022)	(0.041)	(0.055)	(0.060)	(0.048)	(0.037)
Fourth	0.089***	0.127***	–0.115***	–0.072*	0.100*	0.086	0.220**	–0.044	0.089
	(0.016)	(0.041)	(0.014)	(0.037)	(0.060)	(0.082)	(0.093)	(0.072)	(0.056)
N	88,012	45,086	88,012	45,086	1,677	1,677	1,677	1,677	1,677

Notes: Regressions for enrollment and child labor include dummies for age in years and gender of the child. Gross motor skills, fine motor skills, language skills, and social skills are standardized test scores with mean zero and standard deviation one in the full sample. All regressions using test scores as outcome variable include dummies for the gender and age of the child at the moment of the test (in months), in addition we include a dummy which equals 1 if we use test score information collected in the first survey wave. Preschool cognition corresponds to the sum of the scores in the four tests and is standardized to have mean zero and standard deviation one in the full sample. Standard errors (between parentheses) are clustered at the family level; ***significant at 1 percent, **significant at 5 percent, *significant at 10 percent.

and child labor are more pronounced in families where the first-born child is a boy, which goes against the expected birth order pattern driven by parents investing more in sons than in daughters. Instead, these birth order estimates are more consistent with a poverty explanation: If older daughters do not make as much money as older brothers, poor parents have fewer incentives to send their oldest daughter out to work, which results in weaker birth order effects in families with older daughters. We should note that we observe similar, though less pronounced, differences for preschool cognition. Because preschool cognition is measured when children are younger than 6, it is unlikely that a potential earnings advantage for boys is responsible for these differences in estimated birth order effects, unless parents anticipate on these earnings differences.

D. Sensitivity checks

Before we turn to potential mechanisms behind the birth order effects, we first present a number of sensitivity checks. In particular, we test how sensitive the birth order results are to the various sample restrictions we make to reduce measurement error in our birth order measure, and to the incomplete nature of our samples in which we observe families with human capital outcomes of some but not necessarily all children.

In Section III we list the sample restrictions imposed to get the most accurate birth order measure. We next compare our main results to those obtained using samples based on weaker selection criteria. Table 6 below reports these results using our main fixed-effect specification on three different samples.[9] The first Sample A contains all children from families in which we observe the outcome variable for at least two children (allowing us to estimate family-fixed effect regressions) using a birth order measure based on all observed children. The advantage is a sizable sample size, especially for the enrollment and child labor measures where we have a sample of 677,247 observations. The disadvantage is a flawed birth order measure because we ignore all missing children, which directly interferes with the birth order measure we calculate for the observed children. The second Sample B is restricted to families in which we know the number of children the mother gave birth to and where all these children are still alive. The disadvantage is a somewhat smaller sample. The advantage is that we likely obtain a less noisy birth order measure, assuming that the children we do not observe are older than the oldest observed child in the family. The third Sample C contains only those families in which all children of the mother are alive and live at home at the moment of the survey. The disadvantage is again a reduction in sample size. The main advantage, however, is that we work with a birth order measure without error (at least, not according to the survey information). For reasons described in Section III, we further restrict the sample to families with at most four children, which gives us the main samples used in Sections VA and VB.

Table 6 shows that many of the results are very similar to those that have been reported in Tables 2 and 3. Although the estimated birth order effects vary a bit across samples, the estimates for schooling and cognition are generally positive, regardless of the sample we use. One anomaly appears the estimated birth order effect on enrollment using Sample B, which suggests that second-born children do worse than first-born

9. For reasons of brevity, we only report estimates for general preschool cognition, secondary school enrollment, and child labor between age 12 and 18.

Table 6
The Effect of Birth Order on Human Capital Outcomes: Samples Based on Different Sample Selection Criteria

	Secondary School Enrollment (12–18)				Child Labor (12–18)				Preschool Cognition (0–6)			
Sample	A	B	C	Main	A	B	C	Main	A	B	C	Main
Second	0.009***	–0.020***	0.017***	0.008**	–0.019***	0.014***	–0.027***	–0.022***	0.017	0.014	0.021	0.026*
	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.013)	(0.013)	(0.014)	(0.016)
Third	0.047***	–0.001	0.069***	(0.041***	–0.067***	–0.011***	–0.087***	–0.062***	0.035	0.024	0.036	0.045
	(0.003)	(0.004)	(0.005)	(0.006)	(0.003)	(0.003)	(0.005)	(0.005)	(0.022)	(0.022)	(0.025)	(0.028)
Fourth	0.098***	0.036***	0.142***	0.081***	–0.122***	–0.053***	–0.157***	–0.094***	0.054*	0.049	0.062*	0.079*
	(0.005)	(0.006)	(0.008)	(0.011)	(0.004)	(0.005)	(0.007)	(0.009)	(0.033)	(0.034)	(0.037)	(0.042)
Fifth	0.147***	0.078***	0.198***		–0.168***	–0.109***	–0.223***		0.074*	0.060	0.071	
	(0.007)	(0.008)	(0.012)		(0.006)	(0.007)	(0.011)		(0.044)	(0.045)	(0.050)	
Sixth (or later)	0.211***	0.147***	0.291***		–0.219***	–0.185***	–0.313***		0.145**	0.143**	0.192***	
	(0.010)	(0.010)	(0.020)		(0.009)	(0.009)	(0.017)		(0.057)	(0.057)	(0.064)	
N	677,247	426,702	255,068	160,112	677,247	426,702	255,068	160,112	4,933	4,406	3,843	3,250

Notes: In all regressions with preschool cognition as dependent variable, families with more than six children are excluded. Regressions for enrollment and child labor include dummies for age in years and gender of the child. Preschool cognition corresponds to the sum of the scores in the four dimensions of the Nelson-Ortiz test and is standardized to have mean zero and standard deviation one in the full sample. Regressions for preschool cognition include dummies for gender and age of the child in months and a dummy which equals 1 if test score information is collected in the first survey wave. Standard errors (between parentheses) are clustered at the family level; ***significant at 1 percent, **significant at 5 percent, *significant at 10 percent.
Sample A: All children living in families in which the dependent variable is observed for at least 2 children, birth order is computed on basis of children living in the household.
Sample B: Only families in which we know the number of children the mother gave birth to and where all these children are still alive. We assume that children that don't live in the household are older than the oldest child living in the household.
Sample C: Same set of sample selection criteria as in the main samples used in the paper but with unrestricted family size.
Main sample: Sample we use in main analysis in the paper.

children. It is not unlikely, however, that this result is due to a failing assumption (that is, missing children are older than the oldest observed sibling), which has the strongest bite among the oldest children in the family. The estimated birth order effects for child labor follow a comparable (but opposite) pattern. Overall, the results show that our birth order findings are not very sensitive to the sample selection criteria we impose.

The other sample selection issue is related to the incomplete nature of our samples; that is, we observe the human capital outcomes for at least two but not necessarily all children in a family. In the SELBEN we do not observe secondary school enrollment or labor participation for children below age 12 or above age 18. In the ENEVIN we do not observe test scores for children older than six in the first survey round. Conditional on the family fixed effects, whether or not we observe the outcome for a child is fully determined by the age of the child at the moment of the survey. Because we control for age dummies in all specifications, the fact that we do not observe the dependent variable for all children in a family will not result in inconsistent estimates of the birth order effects. But the OLS results shown in Tables 2 and 3 do not include family fixed effects and might therefore suffer from inconsistency due to this sample selection problem.

With heterogeneous effects, however, the estimated birth order coefficients from the family fixed effects models might differ from the estimates we would obtain had we observed the outcomes for all children within each family. To check whether this is an issue, Table 7 shows estimates of the effect of birth order using complete family samples in which we observe the human capital outcome for all children. The fixed effects estimates in Table 7 are very similar to our fixed effects estimates presented in Tables 2 and 3. Table 7 also shows that the OLS estimates and the fixed effects estimates are more similar than the OLS and fixed effects estimates in Tables 2 and 3, indicating that the OLS results in Tables 2 and 3 likely suffer from sample selection bias. In the remainder of the paper we will therefore focus on specifications that include family fixed effects.

VI. What Can Explain the Positive Birth Order Patterns?

In this section we investigate potential explanations for the persistent positive birth order patterns. In Sections VIA and VIB we investigate how mother's time investment and the duration of breastfeeding vary with birth order. In Section VIC we investigate whether important characteristics of developing countries (high poverty rates, low levels of parental education, high teenage pregnancy rates) can explain the positive birth order patterns as well as the sharp difference in birth order patterns between developed and developing countries.

A. *Mother's time investment*

One often mentioned mechanism behind birth order effects is differential time investment by parents. As described in Section II, Price (2008) uses the American Time Use Survey and finds that a first-born child receives significantly more quality time with his or her parent than a second-born child. He concludes that this is a plausible explanation for the negative birth order patterns in educational attainment observed

Table 7
Effect of Birth Order on Human Capital: Only Families Where Outcome Is Observed for All Children

	Enrollment (12–18)		Child Labor (12–18)		Preschool Cognition (0–6)	
	OLS	FE	OLS	FE	OLS	FE
Second	–0.002	–0.004	–0.005	–0.011**	0.043***	0.038*
	(0.005)	(0.006)	(0.003)	(0.005)	(0.015)	(0.021)
Third	0.028***	0.025**	–0.050***	–0.061***	0.096***	0.087**
	(0.008)	(0.011)	(0.006)	(0.009)	(0.025)	(0.037)
Fourth	0.097***	0.095***	–0.115***	–0.131***	0.180***	0.167***
	(0.017)	(0.020)	(0.014)	(0.017)	(0.041)	(0.054)
Family size						
Three	–0.053***		0.047***		–0.071***	
	(0.006)		(0.005)		(0.015)	
Four	–0.156***		0.124***		–0.178***	
	(0.015)		(0.012)		(0.028)	
N	42,617	42,617	42,617	42,617	2,095	2,095

Notes: Estimates are based on samples of families in which the dependent variable is observed for all children of the mother. Regressions for enrollment and child labor include dummies for age in years and gender of the child. Preschool cognition corresponds to the sum of the scores in the four dimensions of the Nelson-Ortiz test and is standardized to have mean zero and standard deviation one in the full sample. Regressions for preschool cognition include dummies for gender and age of the child in months and a dummy which equals 1 if test score information is collected in the first survey wave. Standard errors (between parentheses) are clustered at the family level; ***significant at 1 percent, **significant at 5 percent, *significant at 10 percent.

in the United States (and other developed countries). Differential time investment by parents could also explain the birth order patterns found in this paper provided that the amount of time spent with parents increases instead of decreases with a child's birth order.

To investigate whether time spent with parents varies with a child's birth order, we use information from the second round of ENEVIN. In this second round survey each mother is asked to recall the activities performed on the previous working day. The day is divided in 20 one-hour intervals, from 4 a.m. to midnight, and the mother is asked to mention up to three activities per hour. For each activity information is collected about the duration in minutes, the participation of any family members below the age of 18 and whether the activity was a multitask activity shared with other activities. For multitask activities we rescale the reported duration, such that the sum of the rescaled durations of all activities listed in each interval equals exactly 60 minutes.[10] On the

10. More specifically, we distinguish single-task activities from multitask activities that are done simultaneously with other activities. For single-task activities we use the reported duration. For multitask activities

basis of this information we compute the number of minutes per day that a child spent with his mother.[11]

Table 1 shows descriptive statistics for four measures of mother's time investment. Total time refers to the total amount of time that a child was present during any activity reported by the mother. While total time also includes time spent on activities in which the child was merely present, such as watching TV, cooking, and cleaning the house, quality time includes only the activities in which the child was the main focus of the activity. Similar to Price (2008), we further subdivide quality time and make a distinction between cognitive care and other care. Cognitive care is the type of mother's time investment that is expected to have the biggest impact on human capital of children and includes activities such as playing, reading stories or books, talking, giving advice and helping with homework. Other care includes activities such as feeding, dressing, taking the child to the doctor, and recreational, sports, and religious activities. Table A in the Appendix lists the activities included in each of the four measures of mother's time use. Children spent on average a total of 304 minutes per day with their mother, of which 185 minutes are considered to be quality time. About 30 percent of quality time consists of cognitive care activities.

Table 8 shows fixed effects estimates of the effect of birth order on mother's time investment. Column 1 shows that there is a positive relation between total time spent with the mother and child's birth order but the coefficients are rather imprecisely estimated and not significantly different from zero. If we focus only on activities that can be considered as quality time we see that the positive birth order pattern becomes stronger, and second-born children spent on average significantly more quality time with their mother compared to first-born children. Columns 3 and 4 show the results when we make a distinction between cognitive care and other care. While time spent on other care activities has a negative (but insignificant) relation with birth order, mothers spent significantly more time on cognitive care activities with later-born children. Compared to first-born children, mothers devote about 20 minutes per day more on cognitive activities with fourth-born children. This difference in time investment is about 30 percent of the standard deviation (reported in Table 1) and is therefore substantial. Overall, the cognitive care results, which we consider the most relevant time use category within a childhood cognition framework, are consistent with differential time investment by the mother as possible driver behind the positive birth order patterns observed in preschool cognition and secondary school enrollment.[12]

we rescale the reported duration with a factor equal to (60-sum of duration spent on single-task activities)/sum of duration spent on multitask activities). We have also estimated the effect of birth order on mother's time investment using either reported duration (where the total duration per interval could exceed 60 minutes) or time spent on the main activity reported in each interval. These results, which are very similar to the results shown in Table 8, are available upon request.

11. Following Price (2008), we treat time spent one-to-one with a single child in the same way as time spent with multiple children. We have also estimated the effect of birth order on the average time children spent with their mother, which we calculate by dividing the original time-use measures by the number of children present during the activity. Using this alternative measure of time use we find very similar results, which are available upon request.

12. To better understand how maternal investments respond to the child's endowments, we have also examined the relationship between a child's birth weight and birth order. Birth weight (or a variation thereof) is a typical endowment measure, which is often found to be higher for later-born children with a positive impact on later cognition (Black, Devereux, and Salvanes 2011). In the survey mothers were asked to report for each

Table 8

Estimates of the Effect of Birth Order on Time Spent with Mother and Time Being Breastfed

	Mother's Time Investment (Minutes per Day)				Breastfeeding (Months)	
	Total Time	Quality Time	Cognitive Care	Other Care	FE	Cox FE
Second	5.686	9.000**	10.900***	–1.901	2.615***	–0.552***
	(7.256)	(4.021)	(2.881)	(2.685)	(0.406)	(0.104)
Third	8.058	10.474	13.174**	–2.699	5.744***	–1.304***
	(13.569)	(7.583)	(5.387)	(5.214)	(0.730)	(0.200)
Fourth	15.334	12.803	20.709**	–7.906	8.864***	–2.201***
	(20.668)	(12.034)	(8.356)	(8.421)	(1.088)	(0.315)
N	3,250	3,250	3,250	3,250	3,249	3,249

Notes: All regressions include family fixed effects and dummies for the gender and age of the child (in months). Mother's time investment is collected from a questionnaire that asks mothers to recall the activities performed on the previous working day, whereby a day is divided in intervals of 60 minutes with a maximum of three activities per interval. Data is collected on the duration of each activity in minutes and on which children were participating in an activity. Duration of multitask activities are rescaled such that total time spend per hour equals 60 minutes. Data on breastfeeding is collected retrospectively by asking the mother how many months she breastfed each of her children. Standard errors (between parentheses) are clustered at the family level; ***significant at 1 percent, **significant at 5 percent, *significant at 10 percent.

B. Breastfeeding

There is a large literature that finds a positive effect of breastfeeding on child health in developing countries (Victora et al. 1987; Senauer and Kassouf 2000; Betran et al. 2001). The literature on the effect of the duration of breastfeeding on cognitive outcomes is smaller but also indicates that being breastfed increases educational attainment (Rees and Sabia 2009). If the duration of breastfeeding differs between children with a different birth order, this can also be a potential mechanism behind birth order differences in human capital outcomes.

Table 8 shows fixed effects estimates of the effect of birth order on breastfeeding duration using information from the ENEVIN survey. In the second survey round of ENEVIN, data on breastfeeding is collected by asking the mother how many months she breastfed each of her children. Table 8 shows results for two different specifications. The specification, labeled as FE, estimates the effect of birth order on breastfeeding duration through least squares estimation. Although the age-in-month indicators for the children should take into account that some children in our sample are

of her children whether the child was underweight at birth. If we regress this birth weight measure on birth order and include family fixed effects, together with indicators for gender and age-in-months of the child at the moment of the survey, we find point estimates of –0.010 (0.025), 0.018 (0.043) and 0.059 (0.062) for second-, third- and fourth-born siblings; with standard errors shown in parentheses. These results suggest that the birth order patterns we find cannot be explained by birth weight differences.

still being nursed, we also estimate a stratified Cox proportional hazard model with a family-specific baseline hazard as an alternative solution to the censored breastfeeding durations.[13] Table 8 shows that the duration that a child is being breastfed significantly increases with birth order. The fixed effect results indicate that a fourth-born child is breastfed for about 8 months longer than his or her first-born sibling. Also the negative birth order coefficients from the Cox proportional hazard model show that mothers wean their first-born child much sooner than their later-born children.

These results show that mother's breastfeed later-born children significantly longer than first-born children. These positive birth order patterns are consistent with those found for human capital outcomes and similar to the results found by Jayachandran and Kuziemko (2011) for India.[14]

C. Poverty, parental schooling, and teenage motherhood

We finally ask ourselves to what extent birth order effects vary with characteristics that are prevalent in developing countries, such as lack of financial recourses, low-educated parents and teenage motherhood. Parents can be too poor; if poor parents send their earlier-born children out to work and obtain more resources to allocate to later-born children, then later-born children are more likely to end up having more schooling. First-time parents can be too young and inexperienced; if first-time parents learn and turn into better parents, they may offer their later-born children a more nurturing environment. By this logic we expect that the positive birth order patterns are magnified in poor, low-educated families and in families in which the mother was a teen at first birth. Table 9 reports estimates from fully interacted fixed effects models where all birth order, age, and gender dummies are interacted with variables that indicate whether a family is rich (or less poor), whether the family head has a high level of education, and whether the mother was a teen when she had her first child.

In the top panel we let birth order effects vary with poverty levels. We define a poverty index based on the SELBEN index, which is used by the Ecuadorian government to target programs aimed at helping poor families. The SELBEN index is based on a measure of socioeconomic status that aggregates information about demographic composition, educational attainment, employment, possession of assets and durable goods, dwelling characteristics, and access to services. Families are ranked by their relative position which results in the SELBEN index. Because this index is partly based on endogenous variables such as school enrollment of children and family size, we construct a poverty index that follows the same methodological approach but leaves out these endogenous variables.[15] The resulting poverty index is a variable with values

13. We report coefficients from a Cox proportional hazard model where a negative birth order coefficient implies that mothers are less likely to stop breastfeeding for later-born children.

14. In work related to ours, Jayachandran and Kuziemko (2011) study breastfeeding as a form of contraceptive. If mothers continue to have children (and thus limit breastfeeding) until the preferred number of children is reached, they predict that last born children are breastfed more.

15. We recalculated the weights for the remaining variables in the poverty index using the same methodology (nonlinear principal components) and the same representative sample of all Ecuadorian families applied to construct the SELBEN index. These weights are used to calculate the relative poverty index for each of the families in the SELBEN and the ENEVIN data sets. Table B in the Appendix shows which family characteristics are included in the SELBEN index and which are excluded for the poverty index used in our analyses.

Table 9
Fixed Effects Estimates of Birth Order, Interacted with Indicators of Socioeconomic Status

	Enrollment 12–18	Child Labor 12–18	Preschool Cognition	Enrollment 12–18	Child Labor 12–18	Preschool Cognition
Interaction	Poverty Index Is Above 0.5			Linear Poverty Index		
Second	0.000	–0.017***	0.013	–0.000	–0.034***	–0.018
	(0.004)	(0.003)	(0.018)	(0.010)	(0.009)	(0.060)
Third	0.030***	–0.054***	0.022	0.053***	–0.089***	–0.009
	(0.008)	(0.006)	(0.033)	(0.021)	(0.018)	(0.105)
Fourth	0.067***	–0.081***	0.045	0.138***	–0.136***	0.008
	(0.014)	(0.011)	(0.050)	(0.036)	(0.030)	(0.164)
2nd x interaction	–0.001	0.011**	0.008	–0.012	0.059***	0.062
	(0.006)	(0.005)	(0.033)	(0.022)	(0.019)	(0.130)
3rd x interaction	–0.018	0.022**	0.002	–0.090**	0.119***	0.047
	(0.012)	(0.010)	(0.058)	(0.044)	(0.037)	(0.228)
4th x interaction	–0.039*	0.029*	–0.010	–0.225***	0.178***	0.029
	(0.021)	(0.017)	(0.090)	(0.076)	(0.063)	(0.358)
Interaction	Head Has More than Compulsory Schooling			Linear Schooling of the Head		
Second	0.003	–0.020***	0.023	0.006	–0.025***	0.040
	(0.004)	(0.003)	(0.018)	(0.007)	(0.006)	(0.039)
Third	0.034***	–0.057***	0.036	0.054***	–0.076***	0.038
	(0.008)	(0.007)	(0.032)	(0.014)	(0.012)	(0.067)
Fourth	0.069***	–0.080***	0.058	0.107***	–0.100***	0.064
	(0.014)	(0.012)	(0.049)	(0.025)	(0.021)	(0.099)

2nd x interaction	0.005	0.008	0.001	–0.000	0.001*	–0.003
	(0.006)	(0.005)	(0.036)	(0.001)	(0.001)	(0.005)
3rd x interaction	–0.018	0.029***	0.011	–0.004***	0.004***	–0.002
	(0.012)	(0.009)	(0.063)	(0.001)	(0.001)	(0.008)
4th x interaction	–0.049**	0.039**	0.036	–0.007***	0.005**	–0.004
	(0.022)	(0.017)	(0.095)	(0.003)	(0.002)	(0.012)
Interaction	Mother Was Not a Teen at First Birth			Linear Age of the Mother at First Birth		
Second	0.010*	–0.026***	0.018	0.023	–0.057***	0.098
	(0.006)	(0.005)	(0.022)	(0.018)	(0.015)	(0.089)
Third	0.047***	–0.066***	0.031	0.073**	–0.106***	0.219
	(0.011)	(0.010)	(0.037)	(0.036)	(0.029)	(0.167)
Fourth	0.099***	–0.107***	0.061	0.145**	–0.173***	0.338
	(0.020)	(0.016)	(0.057)	(0.065)	(0.055)	(0.257)
2nd x interaction	–0.004	0.007	0.020	–0.001	0.002**	–0.004
	(0.007)	(0.006)	(0.032)	(0.001)	(0.001)	(0.004)
3rd x interaction	–0.010	0.007	0.032	–0.001	0.002	–0.009
	(0.014)	(0.012)	(0.058)	(0.002)	(0.001)	(0.008)
4th x interaction	–0.029	0.022	0.045	–0.003	0.004	–0.013
	(0.024)	(0.020)	(0.088)	(0.003)	(0.003)	(0.013)

Notes: Estimates come from fully interacted fixed effects models where all birth order dummies and included control variables are interacted with variables that indicate the poverty level, the level of education of the family head, or age of the mother at first birth. Regressions for enrollment and child labor include dummies for age in years and gender of the child. Preschool cognition corresponds to the sum of the scores in the four dimensions of the Nelson-Ortiz test and is standardized to have mean zero and standard deviation one in the full sample. Regressions for preschool cognition include dummies for gender and age of the child in months and a dummy which equals 1 if test score information is collected in the first survey wave. Standard errors (between parentheses) are clustered at the family level; ***significant at 1 percent, **significant at 5 percent, *significant at 10 percent. The number of observations for the enrollment and child labor regressions is equal to 160,112 while for the precognition regressions is equal to 3,250.

between 0 and 1, where a value above 0.5 implies that the family belongs to the richest 50 percent of families in Ecuador.

The first three columns report results where birth order variables are interacted with a dummy variable which equals one if the poverty index is above 0.5. The estimates for school enrollment in the first column show that the positive birth order patterns are indeed strongest in poorer families. The interacted birth order effects, which represent the birth order difference between poorer and richer families, are all negative and especially for later-born children significantly different from zero. The estimates for child labor in the second column are comparable; the birth order effects are particularly strong in poorer families, and significantly stronger than the effects we find in richer families. In contrast, all the birth order effects for preschool cognition in the third column are statistically insignificant and do not suggest that there are any systematic birth order differences between children raised in poorer and richer families.

Since the SELBEN and ENEVIN are surveys targeted at poor families we do not have information about the richest families in Ecuador.[16] To get some idea what the birth order effects would be in those richest families, the last three columns of the top panel show estimates where the continuous poverty index is used as interacting variable. Also with continuous interactions we find birth order effects for child schooling and child labor that are strongest for the very poor families. The birth order estimates for preschool cognition lack precision and are not informative. If we use the estimated interaction terms to predict birth order patterns in families that belong to the richest 10 percent in Ecuador, we find that birth order effects would even reverse for the very rich families. This finding that earlier-born children in poor families, who are sent out to work, would rather go to school had they been raised in rich families is quite remarkable, and suggests that poverty might explain the striking difference in birth order patterns between developed and developing countries. That we do not find much for children in their preschool years does not contradict this story because these children are too young to work.

Another proxy for poverty or financial constraints is parents' education. In the middle panel we report how the effect of birth order varies with the schooling of the head of the family (in most cases the father). In the first three columns we show birth order effects interacted with a dummy variable indicating whether the family head has more than compulsory lower secondary education. The results are very similar to the results in the top panel and show that birth order effects are significantly stronger for children with lower educated family heads. The birth order effects for early child cognition, on the other hand, do not differ much across schooling groups.

In the last three columns we also show birth order effects interacted with a continuous variable measuring the schooling of the head of the family in years. Again, the results are largely similar, showing that the birth order effects on school enrollment and child labor are larger for children born to less-educated parents. As with all the interacted estimates for early childhood cognition, the estimates in the last column are much less precisely estimated and not informative.

Using the estimated interaction terms we can predict birth order patterns for children brought up by family heads with a university degree.[17] In line with the results

16. The 99th percentile of the poverty index is 0.74 in the SELBEN and 0.72 in the ENEVIN.

17. A university degree is equivalent to 17 years of education.

using the poverty index, we find that the birth order effects for secondary school enrollment turn slightly negative. If families with lower educated family heads are more financially constrained than those with more educated family heads, these findings behave as if financial constraints were driving our results.

In the bottom panel in Table 9 we report estimates of the effect of birth order on secondary school enrollment, child labor, and preschool cognition using birth order fixed effects models interacted with either a dummy variable that equals one if the mother was older than 19 when she gave birth to her first child or a continuous variable that measures the mother's age at first birth. As one can see, the interacted birth order effects are all small and not significantly different from zero. Because birth order effects are quite similar for younger and older mothers, the birth order patterns observed in our data have little, if anything, to do with teenage motherhood.

VII. Concluding Remarks

In this paper we have examined the effect of children's birth order on their human capital development from infancy to adolescence in the context of a developing country. The estimates we find allow us to draw four empirical conclusions: (1) later-born children are ahead in their cognitive development in infancy and early childhood; (2) later-born children, in particular those who grow up in poor families, are more likely go to school during their adolescent years; (3) later-born children spend more time with their mothers on cognitive activities; and (4) later-born children are breastfed longer. Taken together, the estimates show that birth order effects in poor families are persistently positive, which is opposite to what is typically found in developed countries. These findings are quite remarkable and probably raise as many questions as they answer.

Why are birth order patterns in developed and developing countries so different? Our findings suggest that financial constraints may be important. If financial constraints drive parents to send their earlier-born children out to work, possibly lifting the constraints for their later-born siblings, we should see that later-born children are more likely to go to school and less likely to work. We indeed find the strongest birth order effects for children growing up in poor, low-educated families. These large effects, accompanied with the reversed birth order effects we find in richer families, make poverty (or the absence thereof) a likely driver behind the birth order divide observed between developing and developed countries.

Why are birth order patterns in developing countries persistently positive? There are a number of possible explanations. One explanation is that the observed birth order differences in preschool cognition and secondary school enrollment are the consequence of observed differences in parental treatments; that is, earlier- and later-born children are born with comparable skills but earlier-born children lag behind because of less maternal and cognitive care. Another explanation is that observed birth order differences in preschool cognition and secondary school enrollment are the cause of observed differences in parental treatments; that is, earlier-born children might already lag behind at birth (because of limited prenatal care) and demand less cognitive care. Although we are unable to empirically separate these explanations, the opposite time investment patterns found in developed countries may suggest that mothers view maternal and cognitive care as an investment leading to differences in their children's cognitive and educational development. Future research, however, should try to distinguish between these two explanations in a more careful way.

And what are the possible implications of these birth order results? Regardless of why earlier-born children raised in poor families stay behind, the fact that they do has clear implications for policymakers. Many nutritional and cash transfer programs, for example, provide nutritional and financial assistance to poor families. These programs are aimed at improving the children's health and human capital. But if improving the conditions for children in need is the main policy objective, then our birth order findings suggest that policies should be designed to improve the conditions of particularly earlier-born children. Our findings also suggest that any serious evaluation of the effectiveness of such policy programs should recognize that there are birth order differentials within families; that is, serious evaluations should take into account that the children's response to these programs might depend on birth order.

Appendix

Table A
Mother's Time Use

	Total Time	Quality Time	Cognitive Care	Other Care
1	Sleeping			
2	Dressing, bathing, grooming			
3	Watch TV or listen to music			
4	Working			
5	Prepare meals or snacks			
6	Breakfast, lunch, snacks	x		x
7	Cleaning the house			
8	Cleaning the dishes			
9	Washing and ironing clothes			
10	Purchase of food			
11	Gathering food (agriculture)			
12	Religious activities	x		x
13	Pay bills, and personal business			
14	Sports activities	x		x
15	Personal entertainment activities			
16	Family entertainment activities	x		x
17	Feeding, dressing and cleaning children	x		x
18	Playing with children, painting, drawing	x	x	
19	Reading stories, books to children	x	x	
20	Helping children with homework	x	x	
21	Talking with the children	x	x	
22	Going to the doctor, taking care of an ill child	x		x
23	Picking up/dropping off			
24	Rest, lying down			
25	Go to health centers or hospitals			
26	Taking care of elderly people			
27	Making phone calls			
28	Attend classes or training courses			
29	Other			

Table B
Variables Included in the SELBEN Index and the Poverty Index Used in the Analysis

	Variables	SELBEN Index	Poverty Index
1	Area (urban/rural)	x	x
2	Quality of the floor	x	x
3	Access to electricity	x	x
4	Shower availability	x	x
5	Access to sanitation	x	x
6	Type of energy used for cooking	x	x
7	Overcrowding	x	
8	Number of children younger than 6 years old	x	
9	Number of income earners	x	
10	Ethnic background of the family head	x	x
11	Educational level of the family head	x	x
12	Access to health insurance of the family head	x	x
13	Educational level of the spouse	x	x
14	Access to credit	x	x
15	Number of children 6 to 15 not enrolled in school	x	
16	Type of school of children 6 to 15 enrolled	x	
17	Number of handicapped family members	x	
18	Land ownership	x	x
19	Availability of a TV	x	x
20	Availability of a DVD	x	x
21	Availability of a car	x	x
22	Availability of a refrigerator	x	x
23	Availability of a stove	x	x
24	Availability of a telephone line	x	x
25	Availability of a stereo	x	x

References

Almond, Douglas, and Janet Currie. 2011. “Human Capital Development Before Age Five.” In *Handbook of Labor Economics*, ed. O. Ashenfelter and D. Card, 1315–486. Amsterdam: Elsevier Science.

Angrist, Joshua D., and Jorn-Steffen Pischke. 2008. *Mostly Harmless Econometrics: An Empiricist’s Companion*. Princeton: Princeton University Press.

Basu, Kaushik, and Pham Hoang Van. 1998. “The Economics of Child Labor.” *American Economics Review* 88(3):412–27.

Betran, Ana P., Mercedes de Onis, Jeremy A. Lauer, and José Villar. 2001. “Ecological Study of Effect of Breast Feeding on Infant Mortality in Latin America.” *British Medical Journal* 323(7308):303–06.

Björklund, Anders, and Kjell G. Salvanes. 2011. “Education and Family Background:

Mechanisms and Policies." In *Handbook of the Economics of Education*, ed. E. Hanushek, S. Machin and L. Woessmann, 201–47. Amsterdam: Elsevier Science.

Black, Sandra E., Paul J. Devereux, and Kjell G. Salvanes. 2005. "The More the Merrier? The Effect of Family Size and Birth Order on Children's Education." *Quarterly Journal of Economics* 120(2):669–700.

———. 2011. "Older and Wiser? Birth Order and IQ of Young Men." *CESifo Economic Studies* 57(1):103–20.

Blake, Judith. 1989. *Family Size and Achievement*. Berkeley: University of California Press.

Booth, Alison L., and Hiau Joo Kee. 2009. "Birth Order Matters: The Effect of Family Size and Birth Order on Educational Attainment." *Journal of Population Economics* 22(2): 367–97.

Conley, Dalton, and Rebecca Glauber. 2006. "Parental Educational Investment and Children's Academic Risk: Estimates of the Impact of Sibship Size and Birth Order from Exogenous Variation in Fertility." *Journal of Human Resources* 41(4):722–37.

Cunha, Flavio, James J. Heckman, Lance Lochner, and Dimitriy V. Masterov. 2006. "Interpreting the Evidence on Life Cycle Skill Formation." In *Handbook of the Economics of Education,* ed. E. Hanushek and F. Welch, 697–812. Amsterdam: Elsevier Science.

Dammert, Ana C. 2010. "Siblings, Child Labor, and Schooling in Nicaragua and Guatemala." *Journal of Population Economics* 23(1):199–224.

De Haan, Monique. 2010. "Birth Order, Family Size and Educational Attainment." *Economics of Education Review* 29(4):576–88.

Edmonds, Eric V. 2006. "Understanding Sibling Differences in Child Labor." *Journal of Population Economics* 19(4):795–821.

Ejrnaes, Mette, and Claus C. Pörtner. 2004. "Birth Order and the Intrahousehold Allocation of Time and Education." *Review of Economics and Statistics* 86(4):1008–19.

Emerson, Patrick M., and André Portela Souza. 2008. "Birth Order, Child Labor, and School Attendance in Brazil." *World Development* 36(9):1647–64.

Galton, Francis. 1874. *English Men of Science: Their Nature and Nurture*. London: Macmillan & Co.

Gary-Bobo, Robert J., Natalie Picard, and Ana Prieto. 2006. "Birth Order and Sibship Sex Composition as Instruments in the Study of Education and Earnings." *CEPR Discussion Papers 5514*.

Gualtiery, Thomas, and Robert E. Hicks. 1985. "An Immunoreactive Theory of Selective Male Affliction." *Behavioral & Brain Science* 8(3):427–41.

Jayachandran, Seema, and Ilyana Kuziemko. 2011. "Why Do Mothers Breastfeed Girls Less Than Boys? Evidence and Implications for Child Health in India." *Quarterly Journal of Economics*, 126(3):1485–538.

Kantarevic, Jasmin, and Stéphane Mechoulan. 2006. "Birth Order, Educational Attainment, and Earnings: An Investigation Using the PSID." *Journal of Human Resources* 41(4):755–77.

Kidd, Sharon A., Brenda Eskenazi, and Andrew J. Wyrobek. 2001. "Effects of Male Age on Semen Quality and Fertility: A Review of the Literature." *Fertility and Sterility* 75(2): 237–48.

Kristensen, Petter, and Tor Bjerkedal. 2007. "Explaining the Relation Between Birth Order and Intelligence." *Science* 316(5832):1717.

Monfardini, Chiara, and Sarah G. See. 2012. "Birth Order and Child Outcomes: Does Maternal Quality Time Matter?" *IZA Discussion Papers DP6825*

Ortiz, Nelson. 1999. "Escala Abreviada de Desarrollo." Technical report, Ministerio de Salud de Colombia y UNICEF.

Price, Joseph. 2008. "Parent-Child Quality Time: Does Birth Order Matter?" *Journal of Human Resources* 43(1):240–65.

Rees, Daniel I., and Joseph J. Sabia. 2009. "The Effect of Breast Feeding on Educational Attainment: Evidence from Sibling Data." *Journal of Human Capital* 3(1):43–72.

Senauer, Benjamin, and Ana L. Kassouf. 2000. "The Effects of Breastfeeding on Health and the Demand for Medical Assistance Among Children in Brazil." *Economic Development and Cultural Change* 48(4):719–36.

Tenikue, Michel, and Bertrand Verheyden. 2010. "Birth Order and Schooling: Theory and Evidence from Twelve Sub-Saharan Countries." *Journal of African Economies* 19(4):459–95.

Victora, Cesar G., J. Patrick Vaughan, Cintia Lombardi, Sandra M.C. Fuchs, Luciana P. Gigante, Peter G. Smith, Leticia C. Nobre, Ana Maria B. Teixeira, Leila B. Moreira, and Fernando C. Barros. 1987. "Evidence for the Protection by Breastfeeding against Infant Deaths from Infectious Diseases in Brazil." *Lancet* 29(8554):319–22.

Zajonc, Robert B. 1976. "Family Configuration and Intelligence." *Science* 192(4236):227–36.