First Among Equals? How Birth Order Shapes Child Development

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ABSTRACT: I study how birth order affects children's academic achievement, personality, and well-being in elementary school. Earlier-born children not only perform better in reading and mathematics throughout elementary school, but they are also more conscientious, agreeable, and emotionally stable, and report higher well-being. Reading ability and conscientiousness – crucial skills for success – appear particularly sensitive to the early childhood environment. These effects are remarkably stable across different groups. I also provide new evidence on the quantity-quality trade-off by showing that family size has a negative effect on earlier-born siblings which enlarges the birth order effect by disproportionately affecting younger siblings.

KEYWORDS: Skill Formation; Parental Investments; Early Childhood; Sensitive Period; Personality; Academic Achievement; Well-being
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1 Introduction

Much of the difference in economic outcomes between individuals can be traced back to childhood and differences in conditions between families (Cunha et al., 2006; Heckman and Mosso, 2014; Falk et al., 2021). But differences also manifest between individuals with similar initial conditions, and perhaps the strongest single piece of evidence for the importance of the childhood environment comes from within the family. It has been repeatedly found that the birth order among siblings is highly consequential for a range of human capital-related outcomes. In particular, first-born siblings on average end up with significantly higher educational attainment, earnings, and employment rate (Black et al., 2005). This is not surprising given that first-borns display higher cognitive ability already at an early age (Pavan, 2016; Lehmann et al., 2018). First-born boys also have higher non-cognitive skills (Black et al., 2018) and lower propensity to commit crime (Breining et al., 2020), while first-born girls are less likely to experience a teenage pregnancy (Black et al., 2005). The variation due to birth order is particularly interesting because it is orthogonal to any genetic differences.[1] Birth order effects may therefore represent the most consistent example of a purely environmental effect on human capital development.

This paper investigates how differences in environments within the family can influence academic achievement, personality development, and subjective well-being. Specifically, I estimate the effect of birth order among children who are siblings and hence equals in terms of other factors usually deemed important for human capital development. I combine Danish population-wide registry data on births and family relations with data from standardized tests and surveys of personality and well-being that all public school children are continuously exposed to. This data allows me to estimate birth order effects on various psychometric outcomes. In particular, my study is the first to use full population data to estimate how birth order affects specific personality dimensions measured using a self-report inventory, which is the standard method in personality psychology (McDonald, 2008).[2] More generally, my study is one of the first to demonstrate the causal origins of divergences in personality traits in a population.

Parental investments are a crucial factor in the development of skills that are important for later-life success (Cunha and Heckman, 2007; Cunha et al., 2010; Heckman and Mosso,

[1] Full siblings have the same expected genetic endowments. It is possible that there could still be systematic differences if children's genetics affect subsequent fertility, but empirically this does not appear to be the case, as a number of studies have found no systematic genetic differences between siblings by birth order (Domingue et al., 2015; Muslimova et al., 2020; Isungset et al., 2021).

[2] For a discussion of the self-report method, its advantages and disadvantages, and a comparison to alternative assessment methods, see Paulhus et al. (2007).

2014), and a number of studies have documented that earlier-born children receive more investments than their later-born siblings. In particular, Price (2008) shows that parents tend to spend more quality time with their children when they are young, but at the same time, parents with more than one child spend roughly the same amount of time with each child at any given point in time, leading to large birth order differences in total time investments. A number of other studies have similarly documented birth order differences with respect to time investments, financial investments and health investments.[3] While differences in parental investments are of course only one of many theoretical explanations for the birth order effect,[4] several studies have demonstrated that birth order differences in cognitive ability can largely be explained by differences in investments (Pavan, 2016; Lehmann et al., 2018).

The skill formation literature stresses the importance of investments early in life, i.e., during the first years of childhood. Early childhood is a sensitive period for the development of various skills, meaning that later remediation for under-investment is costly (Heckman, 2006; Kautz et al., 2014), and a number of empirical studies have confirmed that returns to investments tend to decline with age (Cunha and Heckman, 2008; Cunha et al., 2010; Attanasio et al., 2020; Agostinelli and Wiswall, 2023). The relative importance of early and late investments also differs for different types of skills. Some evidence suggests that the first three years of life are a critical period for cognitive ability, as only investments during this period improve IQ in a lasting way (Heckman and Mosso, 2014; Kautz et al., 2014). More generally, there is evidence that the returns to investments at earlier ages are particularly high for cognitive skills, while the returns to later investments are relatively higher for non-cognitive skills (Cunha and Heckman, 2008; Cunha et al., 2010; Agostinelli and Wiswall, 2023). Similarly, it is generally believed that early life parental investments are particularly important for the development of reading ability relative to ability in mathematics, which conversely is more affected by the school environment (Currie and Thomas, 2001). While there is little evidence that compares the returns to parental investments for reading and

[3]Mothers of later-born children take shorter parental leave and are more likely to be working (Breining et al., 2020). Later-born children also receive less parental supervision (Averett et al., 2011), and parents are less involved in the schoolwork of their later-born children (Black et al., 2018). Financial transfers from parents are also lower for later-born children compared to their earlier-born siblings (De Haan, 2010). Furthermore, later-born children are less likely to be breastfed (Buckles and Kolka, 2014), and they are also less likely to receive preventive medical screenings and to be vaccinated (Pruckner et al., 2021).

[4]Two alternative explanations are biological differences and sibling interactions. Previous studies have found that, if anything, later-born siblings are more healthy at birth (Black et al., 2016; Brenøe and Molitor, 2018; Breining et al., 2020; Pruckner et al., 2021). Nevertheless, I also consider this possibility by estimating birth order effects on birth outcomes in Section 5.3. I do not consider sibling interactions directly, as they are difficult to identify and, as a result, there is little evidence of their importance (see Toppeta (2022) for a recent exception). However, in Section 4, I test the predictions from the evolutionary psychology theory of Sulloway (1995, 1996) about sibling differentiation against those from the skill formation literature.

math directly, some findings are consistent with this notion (Aucejo and Romano, 2016; Ladd and Sorensen, 2017; Chuan et al., 2022).

The empirical literature on skill formation has documented the influence of investments on the development of general domains of ability (e.g., cognitive and non-cognitive skills), but does the formation of specific character skills, such as personality, fit within the same framework? On the one hand, Borghans et al. (2008) and Kautz et al. (2014) argue that personality is similar to cognitive skills in that it is shaped by families, for example through parental investments. Hence, one hypothesis is that, if birth order effects lead to lower levels of investments in later-born children, the later-born siblings will not only have lower academic achievement but also lower character skills in terms of personality.[5] Some evidence from psychology similarly suggests that a lack of parental investments can negatively affect personality development (Martin et al., 2010; Martin and Donnellan, 2021). On the other hand, there is little causal evidence on the origins of differences in personality (Bleidorn et al., 2021). In particular, significant life events in adulthood, such as becoming a parent or even traumatically stressful events, seem to have little effect. But, consistent with the skill formation framework and the importance of early life parental investments, there is evidence that a longer period of full-time parental care during infancy has a positive causal effect on various personality dimensions (Fort et al., 2020; Houmark et al., 2022). However, other theories exist about the effects of birth order on personality. In particular, the predictions from the skill formation framework can be contrasted with an alternative theory from evolutionary psychology which predicts that birth order affects different personality traits in different directions (Sulloway, 1995, 1996).[6]

This paper makes four contributions to the literature. The first contribution is to investigate whether birth order affects personality, and, if so, which theoretical framework the effects are consistent with. I find that there are substantial birth order effects on all personality dimensions that I can measure, as earlier-born children have higher conscientiousness, agreeableness, and emotional stability. I supplement the personality outcomes

[5]This does not imply that a change in personality is either good or bad. A high level of a certain personality trait might be both an advantage or a disadvantage depending on the task. For example, being more extroverted is associated with various positive and negative outcomes. And while agreeableness is thought to be important for own mental health as well as pro-social behavior, it is also negatively related to earnings. On the other hand, high neuroticism (low emotional stability) is generally considered undesirable because it is related to low well-being and a range of other negative outcomes. Similarly, conscientiousness is strongly related to education and other aspects of success and is therefore considered an asset in the same manner as cognitive ability.

[6]This theory states that first-borns will tend to be more motivated to fulfill their parents' expectations while later-borns will tend to be more resistant towards authority and conformity. This leads to the prediction that first-borns will have higher levels of conscientiousness but lower levels of agreeableness and emotional stability (Sulloway, 1995).

with two measures of academic achievement (reading and mathematics) and a measure of well-being and find that earlier-born children score substantially higher on these measures as well. Because of my large sample size, the estimates are highly precise. To my knowledge, this is the first unambiguous evidence that birth order is broadly consequential for personality development.[7][8] The finding that being earlier-born has a positive impact on personality development across the different traits is consistent with the skill formation literature and the role of parental investments in fostering the development of character skills (Borghans et al., 2008; Kautz et al., 2014) and inconsistent with evolutionary theory on sibling differentiation (Sulloway, 1995, 1996). The additional finding that birth order has a substantial impact on children's subjective well-being is also novel. Together, these findings imply that birth order is a highly important source of variation in childhood environments.

A second contribution of the paper is to present suggestive evidence of heterogeneity in the skill formation process. This is made possible by my data where effects on different outcomes are observed at similar ages and the same outcome is observed over time. First, I find that birth order effects are substantially larger for reading than for math achievement, which is consistent with early childhood being a particularly sensitive period for language skills (Cunha et al., 2006), and with the general finding that reading skills are shaped more by parents whereas math skills are shaped more by schools (Currie and Thomas, 2001; Aucejo and Romano, 2016). Similarly, birth order effects on personality are largest for conscientiousness and smallest for emotional stability, suggesting that conscientiousness is particularly sensitive to early life investments. The effects are present already in the earliest grade where I observe them, except in the case of emotional stability, which might instead be shaped more by experiences in adolescence.

My paper also speaks to the theoretical literature on parental investments going back to Becker (1960). The canonical theoretical models of investments in children's human capital formation do not generally predict a negative relationship between birth order and parental investments (Becker and Tomes, 1976, 1986; Behrman et al., 1982; Cunha and Heckman, 2007), and it is somewhat of a puzzle why parents so systematically let their earlier-born children develop an advantage. One explanation is that birth order effects are

[7]Black et al. (2018) show that earlier-born boys score higher on a composite measure of non-cognitive ability at age 18. Higher scores reflect that individuals are deemed more emotionally stable, persistent, socially outgoing, willing to assume responsibility, and able to take initiative. Hence, the measure reflects a combination of various personality traits. An earlier version of the paper also showed effects on four sub-components of this measure, one of which was emotional stability (Black et al., 2016).

[8]There is a long literature in psychology, both theoretical and empirical, on the question of whether birth order affects personality. The empirical literature has typically relied on small samples and produced conflicting results (Sulloway, 2010; Ernst and Angst, 2012). The recent consensus appears to be that birth order has little or no effect on personality (Damian and Roberts, 2015; Rohrer et al., 2015).

only produced by families who face specific constraints on their finances or their time. A third contribution of this paper is to test whether birth order effects are heterogeneous in a way that is consistent with an important role for such constraints. I find that there are substantial birth order effects across all sub-groups that I consider. Regardless of parents' educational length, income, employment status, type of work, etc., their earlier-born children tend to have substantially more favorable outcomes.[9] This suggests that birth order effects are not the result of specific constraints but instead stem from general parental preferences. I present a theoretical framework that can rationalize such behavior as arising because of complementarity in utility from time spent with different children.

Finally, I provide new evidence on the quantity-quality trade-off first formulated by Becker (1960). An implication of this trade-off is that an exogenous increase in family size should decrease average child quality (i.e., child skills) because an increase in quantity increases the shadow price of quality (Becker and Tomes, 1976). Estimation of the family size effect has mainly relied on using twin births as an instrument,[10] but recent work casts doubt on the validity of this method because twin births are correlated with various family characteristics (Bhalotra and Clarke, 2019, 2020). I propose an alternative strategy that circumvents this problem by exploiting variation in the birth of twins *within* the family. In connection with this, I derive a novel hypothesis that relates the literature on fertility to the birth order literature. An exogenous increase in family size should increase the birth order effect among earlier-born siblings because the younger sibling should be more negatively affected than the older sibling. Consistent with this, I show that when a third birth results in twins, rather than a singleton birth, the birth order effect increases. Overall, these findings show how parental time is a limited resource that matters greatly for child development.

The rest of the paper is organized as follows. In Section 2, I describe the data used for the empirical part of the paper and present descriptive statistics. I then describe the empirical strategy in Section 3. I present the main results in Section 4 and additional results in Section 5. Section 6 concludes the paper.

[9] Although birth order effects are sizeable among all sub-groups, they are not completely homogeneous. The largest differences appear for the spacing between siblings, where the birth order effects are significantly larger for all outcomes when the spacing is larger. This lines up well with the evidence from Price (2008) that parental investments follow the same pattern. There is also heterogeneity by income for most outcomes, where the effects are somewhat larger in high-income families. This is consistent with the heterogeneity reported by De Haan et al. (2014).

[10] With somewhat conflicting findings (Black et al., 2005; Angrist et al., 2010; De Haan, 2010; Mogstad and Wiswall, 2016; Bagger et al., 2021).

2 Data

To estimate the effects of birth order, I combine data from different Danish population registers. First off, from the birth register, I obtain information on the date of birth and a personal identifier that links the child, mother, and father. I observe all births in Denmark between 1973 and 2018, but my estimation sample includes only children born between 1993 and 2013 because otherwise, I do not observe any of the main outcomes of interest. However, the fact that I have data on births much prior to this means that I know the actual birth order of each child and not just the birth order within the period of my sample.

In total, I observe 1,512,111 children born between 1993 and 2013. I drop 46,351 of these because of missing information about the identity of their mother or father which is needed to establish family relations. Based on the personal identifiers, I can match children and parents to other registers to obtain information on various background characteristics. From the medical birth register, I obtain information on the parents' age at birth and the child's sex and health at birth, and from the education, earnings, labor market, and immigration registers, I obtain further information on parental background characteristics. I use this information to estimate various heterogeneous effects in Sections 5.1 and 5.3.

In Table 1, I report parental background characteristics for the 1,465,760 children in my gross sample. The summary statistics are reported separately by the total number of children in the family. This reveals that two- and three-child families are positively selected in terms of parental education, income, and employment rate. Each additional increase in family size beyond three children is associated with worse socioeconomic characteristics. One-child families are also negatively selected compared to two-child families. In the main analysis, I restrict my sample to families with at least two children because my estimation strategy relies on comparing siblings. I also drop families with more than five children because there are few of them and the estimates of birth order effects beyond child five will hence be highly imprecise. This leaves 1,255,941 individuals.

I do not observe an outcome for all children in the population. Some enter school too early, some too late, and some do not attend a regular class in a public school during the period from 2010 to 2021 where my outcomes are observed. For 378,359 individuals, I do not observe any outcome, and for a further 236,927, I do observe an outcome of the individual but not of any siblings.[11] Thus, my main sample includes 640,655 individuals. For most of these, I observe the same outcome in multiple grades. Hence, the total number of observations is up to 1,342,844. In Appendix Table A.1, I compare the gross sample to the main sample in

[11]Conditional on belonging to the right cohort, I observe the test scores for 75.4% and the well-being measures for 68.1% of the children in grade 6.

Table 1: DESCRIPTIVE STATISTICS BY FAMILY SIZE

	(1) 1 child	(2) 2 children	(3) 3 children	(4) 4 children	(5) 5 children	(6) 6+ children
Maternal characteristics						
Age at birth	28.869	29.856	30.263	30.784	31.337	32.470
	(5.924)	(4.449)	(4.654)	(5.280)	(5.597)	(5.766)
Immigrant	0.177	0.126	0.168	0.313	0.500	0.674
	(0.382)	(0.332)	(0.373)	(0.464)	(0.500)	(0.469)
Years of education	12.148	12.951	12.874	12.050	11.236	10.771
	(2.493)	(2.460)	(2.609)	(2.721)	(2.713)	(2.683)
Income	188,746	216,762	208,958	187,628	168,202	160,391
	(127,052)	(188,949)	(252,810)	(134,252)	(105,014)	(91,640)
Unemployment	0.070	0.068	0.078	0.101	0.112	0.095
	(0.177)	(0.173)	(0.185)	(0.214)	(0.226)	(0.219)
Paternal characteristics						
Age at birth	32.077	32.375	32.670	33.621	34.670	36.376
	(7.199)	(5.388)	(5.408)	(6.108)	(6.627)	(7.007)
Immigrant	0.166	0.123	0.171	0.321	0.513	0.686
	(0.372)	(0.329)	(0.376)	(0.467)	(0.500)	(0.464)
Years of education	11.939	12.672	12.728	12.184	11.646	11.510
	(2.451)	(2.458)	(2.580)	(2.658)	(2.687)	(2.839)
Income	264,046	300,987	299,365	275,758	234,569	201,756
	(267,309)	(397,143)	(309,411)	(344,202)	(239,775)	(173,812)
Unemployment	0.068	0.048	0.053	0.080	0.110	0.115
	(0.179)	(0.150)	(0.160)	(0.202)	(0.239)	(0.245)
N	187,903	713,389	399,240	111,503	31,809	21,916

Notes: This table reports descriptive statistics of maternal and paternal background characteristics separately by the total number of children in the family.

terms of parental characteristics. This reveals that the average characteristics are similar, although the main sample is slightly positively selected socioeconomically compared to the full population. I also investigate whether there are systematic differences by birth order in the probability that an outcome is missing. As can be seen in Appendix Table A.2, there are only small differences in these probabilities – in particular, they are very similar for the first-born and the second-born.

To obtain the outcomes for the main analysis, I take advantage of two data sources; the Danish National Tests and the Danish Well-being Survey. I describe each in detail in the following.

2.1 The Danish National Tests

In Denmark, elementary school is compulsory from the calendar year when children turn six (grade 0) and until grade 9. At the end of grade 9, there is a school exit exam which determines eligibility for further education. This exam is the first high-stakes test that students are exposed to.

In the school year 2009/2010, a new test system was introduced as mandatory in all public schools. The Danish National Tests (DNT) are low-stakes tests, introduced to provide feedback to teachers and families. The tests are computer-based and automatized, with the final score being a function only of the item difficulties and whether the items are answered correctly. The tests are also adaptive, meaning that the difficulty of items is adjusted based on the student's previous answers. This is done using a Rasch-model algorithm. Questions are alternated between three different topics ("profile areas") in each subject, and a separate test score is estimated for each profile area. The standard error of measurement (SEM) of the test score is also estimated after each question, and the student has to continue with the test until the SEM is below a certain threshold for each profile area.

The tests take place towards the end of the school year, in specific grades depending on the subject. I focus on the tests in reading (grades 2, 4, 6, and 8), and mathematics (grades 3 and 6). The tests in one subject are very similar in format across grades, though the difficulty of the test items is of course adjusted. The profile areas in reading are text comprehension, language comprehension, and decoding, while the profile areas in mathematics are numbers and algebra, geometry, and applied mathematics. To obtain one measure in each grade and subject, I follow the standard procedure to first standardize the score within each profile area, grade level, and school year. I then average over the profile areas and standardize over grade and school year again. This standardized outcome is widely used and highly predictive of later exam performance and educational attainment (Beuchert and Nandrup, 2018).

In Table 2, I report how the achievement measures vary across birth orders and family sizes. Both test score outcomes are measured in 6th grade for comparison. On average, higher birth order and larger family size are both associated with lower academic achievement. Furthermore, family size is in general negatively related to achievement for any given birth order, and vice versa, e.g., first-borns in three-child families score higher than first-borns in five-child families. Hence, a naive regression of test scores on birth order will conflate the effect of birth order with the variation by family size (which in turn is correlated with a range of other characteristics as documented in Table 1). Therefore, the standard approach in the literature on birth order effects is to compare siblings, that is, to use the within-family variation only.

Table 2: NATIONAL TEST SCORES BY BIRTH ORDER AND FAMILY SIZE

	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	2 children	3 children	4 children	5 children	2 children	3 children	4 children	5 children
	Reading				Mathematics			
First born	0.175	0.171	-0.100	-0.415	0.185	0.223	-0.011	-0.275
	(0.942)	(0.975)	(1.112)	(1.086)	(0.977)	(0.999)	(1.037)	(0.989)
Second born	0.063	0.048	-0.152	-0.463	0.084	0.110	-0.083	-0.340
	(0.925)	(0.959)	(1.042)	(1.071)	(0.958)	(0.991)	(1.025)	(1.004)
Third born		-0.005	-0.197	-0.446		0.022	-0.145	-0.372
		(0.963)	(1.039)	(1.072)		(0.973)	(1.026)	(0.996)
Fourth born			-0.176	-0.414			-0.178	-0.397
			(1.013)	(1.035)			(1.004)	(0.981)
Fifth born				-0.410				-0.400
				(1.068)				(1.014)
N	169,143	112,333	32,117	9,124	168,593	112,097	32,044	9,143

Notes: This table reports averages and standard deviations (in parentheses) of the academic achievement measures from the Danish National Tests in grade 6, separately by children's birth order and family size.

2.2 The Danish Well-being Survey

In the school year 2014/2015, a new yearly national survey was introduced to monitor the well-being of students in all grades (0-9) of public elementary schools. The Danish Well-being Survey (DWS) contains 40 items (grades 0-3 receive a simpler, 20-question version) with questions on student well-being and other aspects of their time in school. All responses are given on a five-point Likert scale (three-point in grades 0-3). While participation is voluntary, students are given time to fill out the survey during a class session and are informed that their answers are confidential, and the response rate is above 90 percent.

Although the primary purpose of the DWS is to measure well-being, some of the items in the survey closely resemble items that are typically used to measure personality. Andersen et al. (2020) show that these items can be used to construct measures of three of the dimensions that make up the five-factor model of personality (the "Big Five"), namely conscientiousness, agreeableness, and emotional stability. Conscientiousness is a measure of one's tendency to be self-disciplined, responsible, and diligent, and is the personality dimension most strongly related to education and labor market outcomes. Agreeableness is a measure of one's tendency to be empathetic, cooperative, and unselfish, and is the personality trait most strongly related to peer relations and pro-social behavior. Emotional stability is one's tendency to be calm and robust to stress and anxiety and is the personality dimension most strongly related to happiness and mental well-being.

To obtain a measure of general well-being, I follow Niclasen et al. (2018) who find that most of the items in the DWS load onto four general factors. One in particular, "school connectedness", appears to capture mental well-being. It consists of the three items that also make up the measure of emotional stability, which makes sense given the strong link between emotional stability and mental well-being.[12] In addition, it contains four other items which I combine to create a general measure of well-being. The specific questions for each measure are displayed in Table 3. Each outcome is standardized to make effect sizes comparable to each other and to the outcomes from the DNT.

Table 3: Well-being survey measures

Conscientiousness
How often can you manage the things you set your mind to?
Can you concentrate during lessons?
If I am interrupted during class, I can quickly concentrate again.
Agreeableness
I try to understand my friends when they are sad or angry
I am good at collaborating with others.
Emotional Stability
Do you feel lonely?
How often do you feel safe at school?
Other students accept me as I am.
General Well-being
Do you like your school?
Do you like your class?
I feel that I belong at this school.
Most of the students in my class are kind and helpful.

Notes: This table lists the items from the DWS that are used to construct each of the personality and well-being outcomes.

In Table 4, I again report how the outcomes vary across birth orders and family sizes.

[12] Another factor, "learning self-efficacy", contains all items in the conscientiousness measure and some additional questions about the student's sense of achievement. The last two factors "learning environment" and "classroom management", are more related to external conditions.

All outcomes are measured in 6th grade for comparison. The patterns are similar to the achievement measures in that birth order tends to be negatively related to well-being and each of the personality measures, although this is less clear for the largest families. Larger families also tend to have lower outcomes for any given birth order, except that two-child families have slightly lower outcomes than three-child families. Again, these differences need not represent causal effects, but they show that there are systematic differences across birth order and family size for both academic achievement, personality, and well-being.

Table 4: Personality and well-being by birth order and family size

	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	2 children	3 children	4 children	5 children	2 children	3 children	4 children	5 children
	Well-being				Conscientiousness			
First born	0.189	0.206	0.139	0.043	0.218	0.256	0.236	0.131
	(0.896)	(0.898)	(0.944)	(0.968)	(0.914)	(0.908)	(0.928)	(1.048)
Second born	0.008	0.076	0.030	0.032	0.007	0.086	0.072	0.002
	(0.998)	(0.955)	(0.985)	(1.015)	(0.973)	(0.954)	(0.979)	(1.106)
Third born		-0.014	-0.016	-0.054		-0.023	0.002	0.008
		(1.012)	(1.033)	(1.046)		(0.983)	(0.973)	(1.031)
Fourth born			-0.096	-0.097			-0.113	-0.126
			(1.055)	(1.036)			(1.020)	(1.036)
Fifth born				-0.134				-0.126
				(1.030)				(1.046)
N	73,796	51,573	14,249	4,017	75,635	52,609	14,522	4,099
	Agreeableness				Emotional Stability			
First born	0.121	0.122	0.085	-0.086	0.157	0.173	0.107	-0.017
	(0.914)	(0.916)	(0.933)	(1.062)	(0.900)	(0.899)	(0.922)	(1.052)
Second born	0.007	0.039	-0.021	-0.102	0.014	0.093	0.054	-0.058
	(0.959)	(0.961)	(1.005)	(1.064)	(0.996)	(0.958)	(0.973)	(1.081)
Third born		-0.040	-0.040	-0.080		0.014	0.054	0.005
		(0.989)	(1.001)	(1.095)		(1.007)	(1.002)	(1.055)
Fourth born			-0.105	-0.107			-0.064	-0.021
			(1.025)	(1.079)			(1.084)	(1.021)
Fifth born				-0.151				-0.065
				(1.061)				(1.054)
N	76,030	52,848	14,668	4,187	73,387	51,241	14,072	3,948

Notes: This table reports averages and standard deviations (in parentheses) of the personality and well-being measures from the Danish Well-being Survey in grade 6, separately by children's birth order and family size.

I also consider how the different outcomes are correlated by computing their pairwise correlations. These are displayed in Appendix Table A.3. The correlations are in line with what one would expect theoretically: (1) The two achievement measures are highly correlated.

This is expected because many skills are relevant for succeeding academically regardless of the specific subject. (2) The personality trait most strongly correlated with achievement is conscientiousness. This is expected because self-discipline and diligence are important academic skills. (3) Well-being is most strongly correlated with emotional stability, and these two outcomes have the highest correlation of all. This is expected because being robust to stressors and less prone to negative feelings is obviously conducive to general well-being.

3 Empirical Strategy

Given data on siblings, the birth order effect is in essence just the within-family difference in some outcome between a first-born and a later-born sibling. Comparing children with the same parents ensures that any influence of time-invariant family background is eliminated. Importantly, there are no systematic genetic differences between first and later-born siblings because their genes are inherited from the same parental genetic pool.

One caveat is that earlier-born siblings will (by definition) always be born in earlier years. The birth order effect may hence be conflated with systematic differences across cohorts. For example, birth order effects could appear simply because an outcome is trending (downwards) over time. Because this is not typically considered to be part of the causal effect of birth order that researchers are interested in, it is common to control for the child's year of birth in the regression.

Sometimes, controls for maternal and paternal age at birth are also included. It is less obvious whether this is something that one would want to control for or rather something that is embedded in the birth order effect. In my main specification, I consider it part of the effect because a difference in birth order (excluding twins) necessarily entails a difference in parental age at birth. Hence, I do not control for parental age in the main results. In Appendix 1 (Table A.4), I show that controlling for parental age makes practically no difference.

For each outcome y_i (e.g., 3$^{\text{rd}}$-grade math test scores), I estimate a regression of the form

$$y_i = \alpha + \sum_{k=2}^{5} \beta_k \mathbb{1}[BO_i = k] + \sum_{l=2}^{L} \gamma_l \mathbb{1}[YOB_i = l] + \mu_{f(i)} + \epsilon_i, \tag{1}$$

where BO_i and YOB_i are the birth order and the year of birth of child i, and $\mu_{f(i)}$ is a family fixed-effect indicating whether child i is born into family f (where only full siblings belong to the same family). The β_ks are the coefficients of interest and represent the effect of being a later-born sibling with a specific birth order (between two and five) relative to being the first-born sibling.

For the main results, I report estimates that are pooled over all the grades for which I observe the outcome. The specification is the same as above except that the outcome is now observed in some specific grade $y_{i,t}$, and the family fixed-effect is replaced by a family-by-grade fixed-effect, $\mu_{f(i),t}$, i.e.,

$$y_{i,t} = \alpha + \sum_{k=2}^{5} \beta_k \mathbb{1}[BO_i = k] + \sum_{l=2}^{L} \gamma_l \mathbb{1}[YOB_i = l] + \mu_{f(i),t} + \epsilon_i. \tag{2}$$

In Section 5.2, I test whether the birth order effect is affected by the arrival of twins after a third pregnancy. That is, I estimate the effect of being second-born relative to being first-born and allow this effect to differ depending on whether the third birth is a singleton or a twin birth. This regression takes the form

$$y_{i,t} = \alpha + \beta_2 \mathbb{1}[BO_i = 2] + \gamma \mathbb{1}[BO_i = 2] \times \mathbb{1}[TW3_f = 1] + \sum_{l=2}^{L} \gamma_l \mathbb{1}[YOB_i = l] + \mu_{f(i),t} + \epsilon_i, \tag{3}$$

where $\mathbb{1}[TW3_f = 1]$ is an indicator taking the value one if the third birth in family f is a twin birth and γ is the coefficient of interest capturing the interaction between the birth order effect among the first two siblings and the arrival of twins at the third birth.

4 Main Results

I now proceed to report the main results of the paper. In Table 5, the main birth order effects are displayed for each of the main outcomes, using the specification where the data is pooled across grades. The first takeaway is that substantial birth order effects are present for all outcomes. As expected, first-born children in particular significantly outperform their later-born siblings in reading and mathematics. But they also display higher levels of conscientiousness, agreeableness, emotional stability, and general well-being compared to their siblings when they are in the same grades. Birth order also matters beyond the first-born child, as the second-born has a significant advantage over the third-born for all outcomes, and the same pattern follows for higher birth orders, although the estimates become increasingly imprecise as there are fewer four- or five-child families. There is some indication that the difference between two adjacent siblings decreases with birth order, at least for academic achievement. For personality and well-being, however, the effects are approximately linear. Hence, the exact birth order is consequential even among later-born siblings in larger families.

The effect sizes are substantial, with the difference between the first-born and the second-born ranging from 4.3 percent of a standard deviation for emotional stability to 15 percent of a standard deviation for reading. The latter is comparable to an educational intervention with a relatively large effect.[13] The fact that negative birth order effects (an earlier-born advantage) are present for all outcomes is consistent with the hypotheses from the skill formation framework. Conversely, it is inconsistent with the predictions of Sulloway (1995, 1996) where sibling differentiation should lead to second-borns having higher agreeableness and emotional stability than their first-born siblings. This is novel evidence on the origins of specific personality traits, and it suggests that conscientiousness, agreeableness, and emotional stability fit the definition of character skills, meaning that they are fostered by parental investments, as is the case for cognitive skills.

In so far as birth order differences are due to differences in parental investments, they are also informative about the extent to which these returns differ across different skills. For example, if it is true that reading skills are more sensitive to differences in parental investments than math skills, birth order differences should be larger for reading achievement than for math achievement. Furthermore, if parental investments during the first years of life are particularly important for cognitive skills, whereas later investments are relatively more important for non-cognitive skills, birth order differences in cognitive measures should be present already at a very young age (as documented by Pavan (2016) and Lehmann et al. (2018)), whereas differences on non-cognitive measures such as specific personality dimensions may be less pronounced early in childhood and instead emerge gradually later on. One caveat is that differences in effect sizes (across different measures or over time) could also reflect that the measures are not directly comparable. In Appendix Section 1.2, I discuss some potential limitations and present evidence in favor of the measures being comparable.

The estimates in Table 5 are pooled across grades and hence the average age is not exactly the same for all outcomes. However, the following conclusions are identical if I compare the estimates only in grade 6 where all outcomes are observed (see Appendix Tables A.5–A.7). Consistent with the general notion that parents are particularly important for the development of reading ability (Currie and Thomas, 2001),[14] I find that birth order effects

[13]The differences between the first- and second-born for reading and math are both above the median effect size among 747 educational interventions whose effect sizes were compiled by Kraft (2020).

[14]Parents also report spending more time teaching language than mathematics at home (Cannon and Ginsburg, 2008). There is little empirical evidence, however, that directly estimates how returns to parental investments differ between reading and mathematics, but Chuan et al. (2022) find that an intervention-induced increase in parental investments had a larger positive effect on reading than on mathematics. There

are substantially larger for reading than for mathematics. Among the personality outcomes, the effects for conscientiousness are particularly large and similar in magnitude to those for reading. Hence, two of the skills that are most important for later life success, reading and conscientiousness (Kautz et al., 2014), appear to be particularly sensitive to parental investments. Effects are smaller for the other personality traits, especially emotional stability, which could indicate that factors other than parental inputs are relatively more important for the development of this personality dimension. The substantial birth order effects on well-being are also note-worthy. Not only does birth order have a large impact on skills that are relevant for later success – it also matters greatly for the well-being of children while they are in elementary school.

In Appendix Tables A.5–A.7, I report the estimates separately by grade level. This shows that there are significant birth order effects for all outcomes in almost all grades. The sole exception is that the effect on emotional stability only becomes significant after grade 4. This could reflect that the school years, rather than early childhood, is a sensitive period for emotional stability. The same does not seem to be the case for the other personality dimensions, conscientiousness and agreeableness, however, as effect sizes are similar in grade 4 and grade 8. It is particularly noteworthy that such large effects are present for conscientiousness already in grade 4. This shows that conscientiousness, like cognitive ability, is highly sensitive to the early childhood environment. It also shows how aggregate measures of non-cognitive skills typically used in the skill formation literature miss important heterogeneity in specific character skills.

For reading and mathematics, although most of the effect is also present at the earliest stage, the effect does increase significantly over time, especially for math. This is consistent with dynamic complementarity for cognitive skills, i.e., early (parental) investments increasing the returns to later (school) investments (Cunha and Heckman, 2007; Heckman and Mosso, 2014).[15] It is also consistent with the evidence that school inputs are more important for math than for reading (Aucejo and Romano, 2016; Ladd and Sorensen, 2017). Finally, the birth order effect on well-being is relatively large already in grade 4 but increases further throughout elementary school. The increase could reflect the gradually emerging birth order differences in emotional stability, as emotional stability is closely related to well-being. At the same time, the initial effect implies that other aspects also matter for well-being. It could be that academic achievement or other personality traits also influence well-being, or it could

is also some evidence that math ability is conversely more affected by the school environment (Aucejo and Romano, 2016; Ladd and Sorensen, 2017).

[15]It could also reflect asymmetric cross-productivity of different skills. Specifically, if reading skills enter into the production function for math skills, but not vice versa, as found by Aucejo and James (2021), it could lead to the observed pattern.

Table 5: Effects of birth order on children's outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
	Reading	Mathematics	Well-being	Conscientiousness	Agreeableness	Emotional Stability
Second child	-0.150***	-0.082***	-0.119***	-0.140***	-0.077***	-0.043***
	(0.003)	(0.004)	(0.006)	(0.005)	(0.006)	(0.006)
Third child	-0.238***	-0.144***	-0.185***	-0.209***	-0.139***	-0.064***
	(0.006)	(0.009)	(0.011)	(0.011)	(0.011)	(0.011)
Fourth child	-0.264***	-0.171***	-0.270***	-0.279***	-0.202***	-0.123***
	(0.010)	(0.015)	(0.018)	(0.017)	(0.018)	(0.018)
Fifth child	-0.286***	-0.182***	-0.371***	-0.350***	-0.341***	-0.149***
	(0.018)	(0.025)	(0.031)	(0.030)	(0.031)	(0.031)
N	1,342,844	691,056	819,643	836,905	843,983	813,921

Notes: This table reports parameter estimates of the effect of birth order on the main child outcomes. Standard errors, clustered at the family/grade level, are reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

be that early-life parental investments affect not only the different skills but also well-being directly. It is also noteworthy that the effects on well-being and emotional stability differ so much despite the very high correlation between these two measures (see Appendix Table A.3). This suggests that, even if the two are closely related, they reflect different underlying traits with different production functions.

It is also standard in the birth order literature to report the effects separately by families of different sizes. I do this in Appendix Table A.8. The birth order effects are somewhat larger in smaller families when considering academic achievement (consistent with Black et al. (2005)) while the effects are generally more similar for the non-cognitive outcomes (consistent with Black et al. (2018)), though the effects on emotional stability and well-being also decline slightly with family size. This could reflect that birth order differences in parental investments also tend to decline with family size (Price, 2008). Of course, this need not reflect an effect of family size itself, as family size is endogenous here. I return to the issue of the effect of an exogenous increase in family size in Section 5.2.

5 Mechanisms

Having established the presence of birth order effects across the different outcomes and over time, I now proceed to investigate which circumstances lead to this general pattern of effects. I will not be providing evidence on parental investments as the mechanism producing birth order effects, as this has been done by many other studies (Price, 2008; De Haan, 2010; Averett et al., 2011; Buckles and Kolka, 2014; Pavan, 2016; Black et al., 2018; Lehmann et al., 2018; Breining et al., 2020; Pruckner et al., 2021). Instead, I consider two different questions. First, why are there birth order differences in parental investments? Second, what does the important role of investments imply about the relationship between the birth order effect and the effect of an exogenous increase in family size?

5.1 The Role of Preferences and Constraints

Why do parents invest systematically differently in earlier-born and later-born children? The analysis of the parental investment decision goes back to Becker (1960), who proposed that parents derive utility from the quantity as well as the "quality" of children (e.g., ability) – where the latter can be increased by investments. Because more children entail fewer resources (time or money) to invest in each, this creates the so-called quantity-quality trade-off (Becker and Lewis, 1973). Becker's work is often referenced when seeking to explain the birth order effect. It seems intuitive that first-born siblings will receive more investments because they, for some period of time, are the only child in the household, whereas later-born siblings will always have to share parental resources with their older siblings. However, this argument does not follow from Becker (1960)'s framework unless the later pregnancy is unplanned (i.e., exogenous). If parents are forward-looking, standard economic theory posits that they should invest in each child until the marginal benefit equals the marginal cost (Becker and Tomes, 1976) (see Appendix Section 1.3). Though well-documented empirically, the theoretical literature in economics has not provided a satisfactory explanation for the birth order effect.[16]

Of course, one possible explanation is that parents are constrained in their ability to invest optimally in each child. For example, with the arrival of a second child, optimal investments likely entail that parents should reduce their hours worked or borrow against their future earnings. But some parents will be constrained and unable to make such adjustments. I discuss this in more detail in Appendix Section 1.3, where I also present the alternative explanation that birth order effects arise even in unconstrained families because of fundamental preferences. In Appendix Section 1.4, I develop this argument into a theoretical framework with a concrete example of such parental preferences.[17] Unlike the role of specific

[16] Bagger et al. (2021) develop an elaborate model to describe the relationship between family size and birth order effects. However, this framework is deliberately very general, and the birth order effect is simply ascribed to systematic differences in marginal utilities and marginal costs, which do not necessarily favor earlier-born children. Hence, this does not fundamentally explain the empirical patterns commonly observed.

[17] The idea is, first, that parents derive utility directly from the investments (e.g., they enjoy spending time

constraints, the hypothesis from this framework is that birth order effects are more or less universal. In this section, I test whether birth order effects are present across a range of sub-groups or if they are heterogeneous in ways that are consistent with specific constraints driving the effects.

First, parents may be liquidity-constrained. If so, even if they are able to lower their hours worked, less wealthy parents will have to sacrifice their own consumption or leisure to invest in their child, which might entail that investments are at a sub-optimal level from the child's perspective. As most individuals accumulate wealth over the life course, this mechanism should work against the common pattern of an earlier-born advantage. While this alone cannot explain the birth order effects commonly found, there is some evidence that the effects reverse among very poor families (De Haan et al., 2014).

Second, even if they are not financially constrained, parents might not have the flexibility to adjust their hours worked except at the extensive margin. In that case, parental time investments might be sub-optimal. This mechanism could clearly favor earlier-born children, as time constraints are more likely to be binding with more children in the household. If this is the main reason why later-born children tend to receive fewer parental investments, birth order effects should be more pronounced among parents who have less flexible working arrangements or are otherwise more likely to be constrained with respect to time.

I first investigate whether the birth order effects are heterogeneous across parental income. To do so, I split the sample by whether the combined annual income of the mother and father in the year prior to the birth of the first child ranks above or below the median in the full sample. The results are displayed in Table 6. They reveal that the birth order effects are generally somewhat smaller (more positive) in low-income families. This is consistent with earlier-born children in these families being relatively less advantaged because their parents are more liquidity-constrained. At the same time, for all outcomes, most of the birth order effect remains.

Next, I investigate whether parental time constraints appear important for the emergence of birth order effects. To that end, I estimate the effects across groups defined by various job characteristics. I consider two measures of job flexibility and two measures of work intensity. First, I construct a measure of occupation flexibility by calculating the average within-individual year-to-year variation in number of hours worked.[18] Second, I adopt the

with their children). Second, time spent with one child and time spent with another may be complementary goods (e.g., because of inequality aversion). If so, total investments ironically become skewed towards the first-born child for whom fewer siblings are present on average, and in particular during early childhood where investments tend to be most productive. This is consistent with the empirical patterns documented by Price (2008).

[18]I define the high-flexibility group as those where either the mother or the father works in an occupation

Table 6: Effects of birth order by income

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	High	Low	P-value	High	Low	P-value	High	Low	P-value
	Reading			Mathematics			Well-being		
Second child	-0.158***	-0.137***	0.001	-0.085***	-0.076***	0.329	-0.144***	-0.101***	0.000
	(0.005)	(0.004)		(0.007)	(0.006)		(0.008)	(0.008)	
Third child	-0.262***	-0.211***	0.000	-0.154***	-0.136***	0.349	-0.209***	-0.154***	0.019
	(0.010)	(0.009)		(0.015)	(0.012)		(0.018)	(0.015)	
Fourth child	-0.347***	-0.200***	0.000	-0.233***	-0.142***	0.006	-0.308***	-0.213***	0.019
	(0.019)	(0.014)		(0.027)	(0.019)		(0.032)	(0.025)	
Fifth child	-0.294***	-0.199***	0.063	-0.265***	-0.150***	0.121	-0.381***	-0.309***	0.410
	(0.045)	(0.024)		(0.067)	(0.032)		(0.076)	(0.043)	
N	542,826	665,649		279,012	342,271		324,247	397,115	
	Conscientiousness			Agreeableness			Emotional Stability		
Second child	-0.171***	-0.117***	0.000	-0.085***	-0.075***	0.377	-0.059***	-0.032***	0.017
	(0.008)	(0.007)		(0.008)	(0.008)		(0.008)	(0.008)	
Third child	-0.254***	-0.171***	0.000	-0.140***	-0.145***	0.831	-0.084***	-0.048***	0.124
	(0.017)	(0.015)		(0.018)	(0.015)		(0.018)	(0.015)	
Fourth child	-0.354***	-0.221***	0.001	-0.208***	-0.206***	0.961	-0.135***	-0.091***	0.279
	(0.031)	(0.024)		(0.033)	(0.025)		(0.032)	(0.025)	
Fifth child	-0.533***	-0.265***	0.002	-0.208***	-0.369***	0.069	-0.281***	-0.097**	0.040
	(0.076)	(0.040)		(0.078)	(0.042)		(0.079)	(0.042)	
N	331,249	405,885		333,253	410,238		322,430	393,560	

Notes: This table reports parameter estimates of the effect of birth order on the main child outcomes by income. Standard errors, clustered at the family/grade level, are reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

categorization of Golden (2001) regarding which occupations have the greatest percentage of workers with flexible schedules.[19] Hence, the two measures attempt to capture two different aspects of flexibility with the former being about flexibility in volume and the latter being about flexibility in variability (Kossek and Lautsch, 2018).[20] Finally, to capture heterogeneity

with a standard deviation in hours above two (approximately 40 percent of families).

[19]Specifically, I take the occupations from Table 3 in Golden (2001) and select the corresponding three-digit ISCO-88 codes in my data.

[20]The two measures yield different categorizations in some cases. For example, among men, the most common occupations are trade workers and professionals. Trade workers have high flexibility in volume but low flexibility in variability (e.g., the amount of work varies by season but they always meet early), while professionals have the opposite (e.g., they work many hours but can adjust when they do so). On the other hand, among women, the most common occupations are personal care and secretaries (inflexible in both aspects) and retail and domestic workers (flexible in both aspects).

Table 7: Effects of birth order by flexibility in volume

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	High	Low	P-value	High	Low	P-value	High	Low	P-value
	Reading			Mathematics			Well-being		
Second child	-0.153***	-0.148***	0.435	-0.085***	-0.079***	0.515	-0.131***	-0.109***	0.038
	(0.005)	(0.004)		(0.007)	(0.006)		(0.008)	(0.007)	
Third child	-0.245***	-0.232***	0.310	-0.151***	-0.138***	0.481	-0.192***	-0.176***	0.480
	(0.010)	(0.008)		(0.014)	(0.012)		(0.017)	(0.015)	
Fourth child	-0.311***	-0.245***	0.003	-0.195***	-0.157***	0.214	-0.250***	-0.264***	0.711
	(0.018)	(0.013)		(0.024)	(0.019)		(0.030)	(0.023)	
Fifth child	-0.354***	-0.265***	0.068	-0.310***	-0.153***	0.021	-0.482***	-0.339***	0.071
	(0.044)	(0.021)		(0.061)	(0.030)		(0.070)	(0.037)	
N	544,230	731,741		282,997	373,070	338,094	423,476		
	Conscientiousness			Agreeableness			Emotional Stability		
Second child	-0.148***	-0.134***	0.188	-0.084***	-0.070***	0.188	-0.052***	-0.035***	0.110
	(0.008)	(0.007)		(0.008)	(0.007)		(0.008)	(0.007)	
Third child	-0.219***	-0.202***	0.440	-0.144***	-0.134***	0.659	-0.072***	-0.055***	0.453
	(0.017)	(0.014)		(0.017)	(0.015)		(0.017)	(0.015)	
Fourth child	-0.284***	-0.269***	0.680	-0.179***	-0.207***	0.459	-0.084***	-0.128***	0.245
	(0.029)	(0.022)		(0.030)	(0.023)		(0.030)	(0.023)	
Fifth child	-0.422***	-0.324***	0.190	-0.353***	-0.340***	0.865	-0.221***	-0.133***	0.266
	(0.066)	(0.035)		(0.067)	(0.037)		(0.070)	(0.037)	
N	345,584	432,982		348,649	436,822		335,800	420,181	

Notes: This table reports parameter estimates of the effect of birth order on the main child outcomes by occupation flexibility in volume. Standard errors, clustered at the family/grade level, are reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

in work intensity, I use employment status, specifically whether either parent works part-time and whether either parent is unemployed. I measure employment status before the birth of the first child, but condition on employment status before the birth of the specific child. Hence, I estimate whether the birth order effects are smaller when, for example, a parent works part-time prior to the birth of both children than if both parents work full-time prior to the birth of both children.[21]

The results are reported in Tables 7-10. In all cases, the results are inconsistent with time constraints being the main cause of birth order effects. First, Table 7 shows that

[21] Because employment status after the first birth is potentially endogenous, I also estimate the effects without conditioning on this variable. These results are reported in Appendix Tables A.9-A.10 and are similar to the results reported here.

Table 8: Effects of birth order by flexibility in variability

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	High	Low	P-value	High	Low	P-value	High	Low	P-value
	Reading			Mathematics			Well-being		
Second child	-0.153***	-0.135***	0.013	-0.076***	-0.078***	0.854	-0.126***	-0.116***	0.413
	(0.006)	(0.004)		(0.009)	(0.006)		(0.010)	(0.007)	
Third child	-0.243***	-0.208***	0.022	-0.145***	-0.140***	0.817	-0.184***	-0.172***	0.634
	(0.013)	(0.008)		(0.018)	(0.012)		(0.021)	(0.014)	
Fourth child	-0.290***	-0.197***	0.001	-0.169***	-0.148***	0.578	-0.222***	-0.232***	0.824
	(0.023)	(0.015)		(0.032)	(0.020)		(0.037)	(0.025)	
Fifth child	-0.400***	-0.198***	0.004	-0.344***	-0.152***	0.047	-0.315***	-0.310***	0.963
	(0.061)	(0.035)		(0.087)	(0.042)		(0.094)	(0.054)	
N	366,340	762,853		190,908	397,612		222,230	477,202	
	Conscientiousness			Agreeableness			Emotional Stability		
Second child	-0.151***	-0.134***	0.164	-0.099***	-0.068***	0.011	-0.040***	-0.046***	0.623
	(0.010)	(0.007)		(0.010)	(0.007)		(0.010)	(0.007)	
Third child	-0.215***	-0.198***	0.501	-0.160***	-0.129***	0.219	-0.072***	-0.063***	0.721
	(0.021)	(0.014)		(0.021)	(0.014)		(0.021)	(0.014)	
Fourth child	-0.295***	-0.239***	0.196	-0.244***	-0.172***	0.103	-0.067*	-0.122***	0.218
	(0.036)	(0.024)		(0.037)	(0.024)		(0.037)	(0.025)	
Fifth child	-0.370***	-0.330***	0.680	-0.446***	-0.297***	0.147	-0.033	-0.163***	0.196
	(0.082)	(0.052)		(0.088)	(0.053)		(0.084)	(0.055)	
N	222,230	487,549		228,595	492,203		220,895	473,536	

Notes: This table reports parameter estimates of the effect of birth order on the main child outcomes by occupation flexibility in variability. Standard errors, clustered at the family/grade level, are reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

there is little heterogeneity by flexibility in volume. If anything, the birth order effects are slightly larger for families working in high-flexibility occupations, even though these families should be less time-constrained. A very similar pattern appears for flexibility in variability, as shown in Table 8. The similarity in the results is fairly striking because the two categorizations are only weakly correlated and flexibility in volume is negatively correlated with educational attainment ($r = -0.20$) while flexibility in variability is positively correlated with educational attainment ($r = 0.19$) (which matches the general notion that workers with flexibility in volume are negatively selected and workers with flexibility in variability are positively selected (Golden, 2008; Kossek and Lautsch, 2018)). Hence, the results on flexibility are inconsistent with birth order effects appearing because of time constraints.

Second, Table 9 shows how the effects differ depending on whether or not at least one of

Table 9: Effects of birth order by type of work

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Part time	Full time	P-value	Part time	Full time	P-value	Part time	Full time	P-value
	Reading			Mathematics			Well-being		
Second child	-0.153***	-0.144***	0.314	-0.089***	-0.079***	0.442	-0.147***	-0.112***	0.015
	(0.008)	(0.004)		(0.012)	(0.005)		(0.013)	(0.006)	
Third child	-0.268***	-0.220***	0.005	-0.184***	-0.132***	0.028	-0.237***	-0.160***	0.006
	(0.015)	(0.008)		(0.021)	(0.011)		(0.025)	(0.013)	
Fourth child	-0.310***	-0.222***	0.001	-0.240***	-0.144***	0.013	-0.264***	-0.250***	0.768
	(0.024)	(0.013)		(0.034)	(0.018)		(0.042)	(0.022)	
Fifth child	-0.338***	-0.206***	0.010	-0.291***	-0.145***	0.039	-0.422***	-0.342***	0.381
	(0.046)	(0.023)		(0.063)	(0.032)		(0.082)	(0.040)	
N	273,102	935,373		143,830	477,453		171,312	550,050	
	Conscientiousness			Agreeableness			Emotional Stability		
Second child	-0.140***	-0.137***	0.834	-0.091***	-0.072***	0.185	-0.071***	-0.037***	0.018
	(0.013)	(0.006)		(0.013)	(0.006)		(0.013)	(0.006)	
Third child	-0.234***	-0.194***	0.143	-0.162***	-0.137***	0.375	-0.131***	-0.044***	0.002
	(0.024)	(0.013)		(0.025)	(0.013)		(0.025)	(0.013)	
Fourth child	-0.274***	-0.272***	0.965	-0.218***	-0.207***	0.813	-0.133***	-0.110***	0.621
	(0.040)	(0.021)		(0.041)	(0.022)		(0.041)	(0.022)	
Fifth child	-0.452***	-0.325***	0.160	-0.375***	-0.351***	0.794	-0.210**	-0.136***	0.444
	(0.082)	(0.038)		(0.083)	(0.040)		(0.088)	(0.040)	
N	174,986	562,148		176,550	566,941		170,186	545,804	

Notes: This table reports parameter estimates of the effect of birth order on the main child outcomes by type of work prior to the birth of the first child, controlling for type of work prior to the birth of the specific child. Standard errors, clustered at the family/grade level, are reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

the parents is working part-time. The pattern is again similar to the two flexibility measures in that there is little heterogeneity and, if anything, the effects are somewhat larger in the part-time group, which goes against the time constraints explanation. Finally, Table 10 shows how the effects differ by parental employment status. Note that unemployed parents should be less time-constrained but, at the same time, more liquidity-constrained. Both factors should go in the direction of smaller birth order effects. The fact that there are only minor differences in academic achievement and no differences in personality and well-being is hence a strong indication that these constraints are not a major driver of birth order differences.

Table 10: Effects of birth order by employment status

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Unemployed	Employed	P-value	Unemployed	Employed	P-value	Unemployed	Employed	P-value
	Reading			Mathematics			Well-being		
Second child	-0.126***	-0.154***	0.002	-0.061***	-0.087***	0.031	-0.117***	-0.117***	0.999
	(0.008)	(0.004)		(0.011)	(0.005)		(0.014)	(0.006)	
Third child	-0.210***	-0.241***	0.068	-0.107***	-0.158***	0.025	-0.176***	-0.175***	0.973
	(0.015)	(0.008)		(0.020)	(0.011)		(0.027)	(0.013)	
Fourth child	-0.238***	-0.245***	0.798	-0.109***	-0.189***	0.029	-0.223***	-0.264***	0.388
	(0.024)	(0.013)		(0.032)	(0.018)		(0.042)	(0.022)	
Fifth child	-0.273***	-0.222***	0.317	-0.096*	-0.208***	0.093	-0.396***	-0.355***	0.631
	(0.045)	(0.024)		(0.058)	(0.033)		(0.075)	(0.041)	
N	258,946	949,529		128,436	492,847		134,200	587,162	
	Conscientiousness			Agreeableness			Emotional Stability		
Second child	-0.133***	-0.142***	0.530	-0.087***	-0.075***	0.431	-0.034**	-0.042***	0.600
	(0.013)	(0.006)		(0.014)	(0.006)		(0.014)	(0.006)	
Third child	-0.191***	-0.212***	0.470	-0.157***	-0.138***	0.526	-0.059**	-0.063***	0.894
	(0.026)	(0.013)		(0.027)	(0.013)		(0.027)	(0.013)	
Fourth child	-0.213***	-0.296***	0.072	-0.198***	-0.218***	0.679	-0.067	-0.131***	0.177
	(0.041)	(0.021)		(0.043)	(0.022)		(0.042)	(0.022)	
Fifth child	-0.311***	-0.366***	0.497	-0.393***	-0.349***	0.607	-0.154**	-0.158***	0.963
	(0.071)	(0.039)		(0.075)	(0.041)		(0.074)	(0.041)	
N	137,397	599,737		138,656	604,835		133,259	582,731	

Notes: This table reports parameter estimates of the effect of birth order on the main child outcomes by employment status prior to the birth of the first child, controlling for employment status prior to the birth of the specific child. Standard errors, clustered at the family/grade level, are reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5.2 Birth Order and Family Size

The first prediction from the framework of Becker (1960) is a negative correlation between family size and child "quality". This is not a causal effect but a result of parents sorting into different family types based on preferences.[22] A second prediction from this framework, however, is that an exogenous increase in family size will have a negative causal effect on the quality of the other children in the household. This happens because an increase in child quantity increases the shadow price of quality (Becker and Tomes, 1976). This prediction has

[22]The main feature that Becker (1960)'s model seeks to explain is the negative association between income and fertility. This follows from the quantity-quality trade-off and from a high (low) income elasticity for child quality (quantity).

been extensively investigated empirically, typically using an instrument for fertility (yielding mixed findings (Black et al., 2005; Angrist et al., 2010; De Haan, 2010; Mogstad and Wiswall, 2016; Bagger et al., 2021)). The two commonly used instruments are twin births and sibling sex composition. However, recent work has shown that the assumptions required for these instruments to be valid are unlikely to hold in practice because of violations of independence[23] and either the exclusion restriction or monotonicity.[24]

I now present an additional novel hypothesis that relates the effects of family size and birth order. Theoretically, an exogenous increase in family size should not only lead to lower child outcomes on average (as in Becker (1960)), but it should also have a more adverse effect on the youngest sibling. The increase in quantity increases the shadow price of quality (Becker and Tomes, 1976). But because skill development in childhood is a dynamic process (Kautz et al., 2014), this will be more consequential the younger the earlier-born children are at the time of the exogenous increase. For example, if the first-born child is already of school age, any reduction in investments will be less consequential for him than for his sibling who is still in early childhood (particularly if investments during the early years have the highest returns, as much evidence suggests (Heckman, 2006; Heckman and Mosso, 2014)). Hence, an exogenous increase in family size is hypothesized to increase the birth order effect among earlier-born siblings.

To test this hypothesis, I also exploit the birth of twins, but instead of using it as an instrument for total family size, I use it as exogenous variation in the exposure to siblings *within* the family. Specifically, I focus on the first two children in families with three or more children. While I restrict the sample to families where the first two children are singletons, the third pregnancy may or may not result in a multiple birth. I thus investigate whether the birth order effect among the first two siblings is magnified when the third birth is a multiple birth, relative to when it is a singleton birth. Because the comparison remains within families, it eliminates the influence of any unobserved characteristics of the parents that may affect the probability of having twins.[25] While this does not recover the causal effect of an increase in family size on either the first-born or the second-born, it recovers the

[23]For the twins instrument, Bhalotra and Clarke (2019) use data from 72 countries to show that mothers who give birth to twins are positively selected on a range of different health measures. This holds across countries and for women who do not use in vitro fertilization. Bhalotra and Clarke (2020) argue that this almost certainly biases estimates of the effect of family size using the twins instrument towards zero.

[24]For the sibling sex composition instrument, the exclusion restriction imposes that the sex composition of children only affects a certain outcome through an effect on fertility (see, e.g., the discussion in Rosenzweig and Wolpin (2000)). Furthermore, the monotonicity assumption essentially requires not only that the average couple has a preference for a mixed-sex composition, but that no parents prefer having two boys or two girls (for more detail, see, e.g., the discussion in De Chaisemartin (2017)).

[25]An equivalent strategy is used by Black et al. (2021) to estimate the effect of differential exposure among siblings to a disabled third-born child.

extent to which the second-born is *more* affected by the increase in family size. Theoretically, the twin birth should have a (possibly weak) negative impact on the first-born and a stronger negative impact on the second-born. Assuming a weakly negative effect on the first-born, the additional impact on the second-born also becomes a lower bound on the causal effect of an increase in family size on the second-born. Importantly, this estimate does not suffer from the potential biases that previous estimates of the effect of family size are susceptible to because of the non-random nature of twin births.

The estimates are displayed in Table 11. For all outcomes, I find that the birth order effect is more pronounced in families where the third birth is a multiple birth. Although fairly imprecisely estimated, this difference is significant for four of the six outcomes. While there are some differences in magnitudes for the different outcomes, the confidence intervals are all overlapping, and the estimates are hence consistent with an effect of around 6 percent of a standard deviation on all outcomes. That is, when a twin birth leads to an increase in family size from two to four instead of from two to three, the second-born child is negatively affected on all outcomes by around 6 percent of a standard deviation *relative to the effect on the first born*. If the first-born is also negatively affected by the increase in family size, the total effect on the second-born will be the combination of this effect and the additional effect of minus 6 percent. It seems plausible that a twin birth (relative to a singleton birth) should at least not have a positive effect on the first-born. If so, this is also indirect evidence of a family size effect more generally, and hence consistent with the classical child quantity-quality trade-off (Becker, 1960; Becker and Tomes, 1976).

While exposure to twin births is plausibly random within the family, a potential limitation of this approach is that it is susceptible to the birth order effect being different in families with and without twins because of other characteristics that are correlated with the probability of having twins.[26] I have shown earlier that there is little heterogeneity in the birth order effect based on observable family characteristics. Nevertheless, as a robustness check, I re-estimate the results in Table 11 using a smaller sample of non-twin families which are matched based on the observable characteristics in Table 1 to be similar to the families with twins. Specifically, I use propensity score matching to identify the ten nearest neighbors for each family with twins at the third birth.[27] As can be seen in the bottom panel of Table 11, the estimates of the family size effect on this sample are all very similar to the estimates using the full sample. This lends further support to the estimates representing a causal effect

[26] It could also be that the birth order effect is heterogeneous across family size in general, meaning that the estimates pick up a difference in birth order effects between 3- and 4-child families. However, because the birth order effect is generally smaller in 4-child families (see Appendix Table A.8), this would bias my estimates towards zero.

[27] The estimates are similar if I use Mahalanobis matching instead of matching on the propensity score.

Table 11: Effects of differential exposure to twins

	(1)	(2)	(3)	(4)	(5)	(6)
	Reading	Mathematics	Well-being	Conscientiousness	Agreeableness	Emotional Stability
Second child	-0.142***	-0.073***	-0.098***	-0.132***	-0.069***	-0.033***
	(0.007)	(0.010)	(0.011)	(0.011)	(0.011)	(0.011)
Second × multiple third	-0.029	-0.087**	-0.092**	-0.063*	-0.042	-0.077**
	(0.024)	(0.034)	(0.038)	(0.036)	(0.038)	(0.037)
N	325,044	167,096	194,881	199,617	201,501	193,029
Matched sample:						
Second child	-0.165***	-0.060*	-0.117***	-0.171***	-0.056	-0.025
	(0.025)	(0.036)	(0.039)	(0.039)	(0.041)	(0.039)
Second × multiple third	-0.022	-0.084**	-0.096**	-0.067*	-0.048	-0.107**
	(0.027)	(0.040)	(0.042)	(0.040)	(0.042)	(0.041)
N	31,395	15,947	18,445	18,894	19,008	18,278

Notes: This table reports parameter estimates of the effect of being second born on the main child outcomes, depending on whether the third pregnancy results in a single or a multiple birth. Standard errors, clustered at the family/grade level, are reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

of an exogenous increase in family size on the second-born child.

5.3 Additional Results

In this section, I report a few additional results. First, I consider whether the birth order effects differ between boys and girls. Some earlier findings suggest that boys are more sensitive to differences in investments or in the quality of the childhood environment more generally (Bertrand and Pan, 2013; Chetty et al., 2016; Autor et al., 2019). In Appendix Table A.11, I report estimates of the birth order effects separately for boys and girls. Although the effect sizes are fairly similar, I do find that the effects of birth order are significantly stronger for girls for reading and emotional stability. The effects are also somewhat larger for conscientiousness and well-being, although this difference is not statistically significant for the second-born. While this is somewhat in contrast to the findings that boys are more sensitive to the environment, it is consistent with the sex differences in the birth order effects that Black et al. (2005) find for educational attainment and labor market outcomes.

Next, I consider whether the effects differ for families with high and low educational attainment.[28] These results are reported in Appendix Table A.12. As for all previously

[28]The median educational length is 12 years for both parents. I define high education as an average length

reported results on heterogeneous effects, the differences across educational levels are modest. The birth order effects are somewhat larger among children of highly educated parents for academic achievement (especially reading) and conscientiousness. This is similar to Black et al. (2005) who also find comparable but, if anything, larger effects among the more highly educated. This could reflect dynamic complementarity where higher initial skills increase the returns to subsequent investments (Cunha and Heckman, 2007). Dynamic complementarity might be present for some skills but not others. Indeed, well-being and the remaining personality traits do not follow this pattern.

Another potential source of variation in the birth order effect is the spacing between siblings. Price (2008) finds that differences in parental investments by birth order increase with the spacing between siblings. This makes sense if parents partly equalize investments among all siblings present, as siblings born in close succession will then receive the same level of investments for most of their childhood. Intuitively, the advantage that the first-born has of being the only child is much shorter. Consistent with this, Appendix Table A.13 shows that the birth order effect is smaller for all outcomes if the spacing between the two oldest siblings is less than two years.

Finally, in Appendix Table A.14, I check whether there are birth order effects on children's health-related birth outcomes.[29] If first-borns are more healthy at birth, this could represent an alternative mechanism driving the other birth order effects. On the contrary, I find that, if anything, first-borns are somewhat disadvantaged with respect to health at birth, having lower birth weight and lower APGAR scores than their later-born siblings. This is consistent with a number of other studies on birth order and health at birth (Black et al., 2016; Brenøe and Molitor, 2018; Breining et al., 2020; Pruckner et al., 2021). Interestingly, I also find that mothers are somewhat more likely to smoke during their first pregnancy than during their second or third. Smoking during pregnancy is a (negative) prenatal parental investment; hence, this suggests that the first-born advantage is not caused by differences in investments prior to birth.

6 Conclusion

While differences in resources between families are generally considered the fundamental source of social inequality, within-family differences also contribute to individual thriving.

above 12 years.

[29]Because parental age at birth might be particularly consequential for health-related outcomes, I also report estimates from the specification where I control for parental age. This does not change any of the estimates substantively.

One particularly striking finding is that birth order has a large impact on a range of outcomes in adulthood. In this paper, I show that such birth order effects are present already during elementary school, with large effects on both academic achievement (reading and math ability), personality (conscientiousness, agreeableness, and emotional stability), and subjective well-being. Hence, birth order is broadly consequential for individual cognition and behavior. Importantly, birth order is not only relevant for later life success, but it also matters for psychological and socio-emotional well-being among children.

Previous studies have shown that birth order matters because it affects the level of parental investments during childhood (Price, 2008; Pavan, 2016; Lehmann et al., 2018). But why do earlier-born siblings receive more investments? One hypothesis is that birth order differences only manifest if parents are constrained with respect to time or liquidity, which should lead to specific patterns of heterogeneity. In contrast, I show that birth order effects are remarkably stable across different groups. This is summarized in Appendix Figure A.1. Earlier-born siblings have more favorable outcomes on all dimensions regardless of their parents' educational length, income, employment status, and so on. This suggests that birth order effects do not surface because certain families are faced with specific constraints such as limitations on borrowing or inflexible working arrangements. An alternative explanation, consistent with the striking homogeneity, is that parental preferences for dividing their time equally among all their children on any given day ironically leads to an unequal distribution of total time investments.

I also show that birth order effects are sensitive to a shock to family size. Theoretically, an increase in family size should reduce the time invested in earlier-born siblings, but previous findings have not supported a causal effect of family size, partly because of the difficulty of finding exogenous variation in the number of siblings. I take advantage of the arrival of twins being plausibly exogenous *within* the family. I show that the arrival of twins at the third birth, relative to a singleton birth, has a more negative impact on the second-born sibling than on the first-born. This is again consistent with the notion that the differences among siblings that I consider are neither due to birth order nor family size per se, but rather a result of how both factors are decisive for the number of siblings that are present in the household at a given point in time, which in turn leads to differences in parental investments received at specific stages of childhood.

My findings shed new light on the causes of individual psychological differences. While the skill formation literature has illuminated how general measures of ability (e.g., cognitive and non-cognitive skills) are shaped by the childhood environment (see, e.g., Heckman and Mosso, 2014), there is still little empirical evidence on the origins of specific personality traits (Bleidorn et al., 2021). A few recent studies find evidence that is consistent with the important role of parental investments in shaping personality (Akee et al., 2018; Fort et al., 2020; Houmark et al., 2022). On the other hand, severe parental health shocks and other extreme environmental events appear to have little effect on personality development (Sutin et al., 2020; Damian et al., 2021; García-Miralles and Gensowski, 2023). My findings are hence consistent with this small literature in placing parental investments as a central cause of individual differences in personality. My results also go against some of the theoretical psychology literature on how siblings differentiate themselves based on birth order. Specifically, based on evolutionary psychology, Sulloway (1995, 1996) hypothesizes that firstborns should have higher conscientiousness, but lower agreeableness and emotional stability than their later-born siblings. My findings show that any such sibling differentiation effect is dominated by the fact that conscientiousness, agreeableness, and emotional stability are all being affected positively by a common factor associated with birth order, presumably parental investments.

While all dimensions of achievement and personality are malleable, my results reveal important heterogeneity. Reading skills appear more sensitive to parental investments than math skills. This lends further support to the notion that reading skills are more sensitive to the home environment whereas schools play a more important role in math skill development. Among the personality dimensions, conscientiousness is most affected by birth order. This suggests that, among character skills, parental investments are particularly important for the formation of conscientiousness, which happens to be the personality trait that is most predictive for a range of later outcomes (Borghans et al., 2008; Almlund et al., 2011). On the other hand, birth order effects on emotional stability only appear gradually, suggesting a more important role of the adolescent environment for this specific trait. However, a limitation of this paper is that I do not observe parental investments and hence cannot estimate their impact directly. More research is needed to unravel the formation of specific character skills. To this end, I caution against a narrow focus on resource-based explanations. The fact that birth order effects appear almost universally suggests that future research might benefit from paying more attention to the role of preferences and behavior in shaping individual outcomes.

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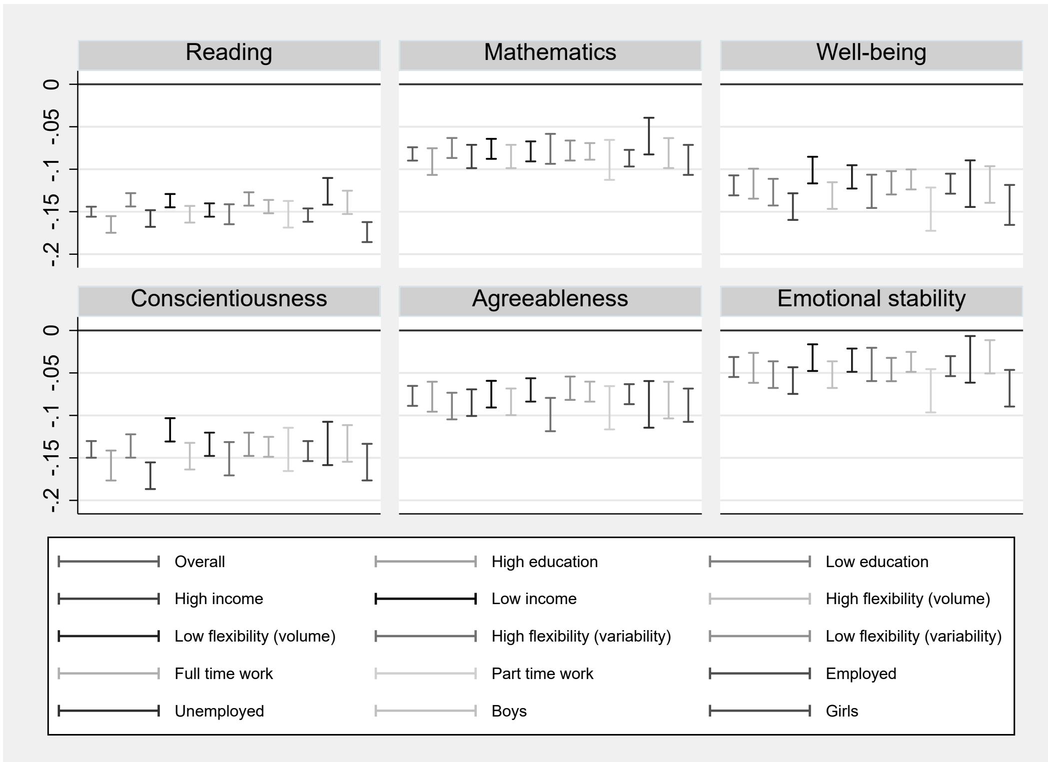
1 Appendix

1.1 Additional results

Figure A.1: Effects of birth order by outcome and group



Notes: This figure plots the point estimates and 95 percent confidence intervals for the effect of being second born, relative to being first born, on each of the main outcomes and across all subgroups.

Table A.1: Descriptive statistics and sample selection

	(1) Main sample	(2) Gross sample
Maternal characteristics		
Age at birth	29.783	30.095
	(4.445)	(4.629)
Immigrant	0.141	0.165
	(0.348)	(0.372)
Years of education	12.959	12.816
	(2.521)	(2.558)
Income	215,479	210,748
	(184,730)	(206,808)
Unemployment	0.061	0.075
	(0.158)	(0.182)
Paternal characteristics		
Age at birth	32.311	32.622
	(5.252)	(5.506)
Immigrant	0.143	0.166
	(0.350)	(0.372)
Years of education	12.713	12.628
	(2.488)	(2.527)
Income	304,890	296,843
	(419,109)	(364,040)
Unemployment	0.045	0.054
	(0.144)	(0.161)
N	640,655	1,255,941

Notes: This table reports descriptive statistics of the maternal and paternal background characteristics for the main estimation sample compared to the gross sample which includes all children in 2 to 5-child families born between 1993 and 2013.

Table A.2: Missing outcomes by birth order and family size

	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	2 children	3 children	4 children	5 children	2 children	3 children	4 children	5 children
	Test score missing Born 1998-2005				Well-being missing Born 2003-2007			
First born	0.235	0.257	0.338	0.419	0.309	0.314	0.362	0.426
Second born	0.233	0.249	0.320	0.380	0.318	0.317	0.358	0.409
Third born		0.236	0.285	0.351		0.316	0.342	0.364
Fourth born			0.260	0.312			0.336	0.361
Fifth born				0.299				0.358
N	265,578	159,220	46,285	13,560	169,260	99,020	26,733	7,427
	Born 1993-2013				Born 1993-2013			
First born	0.606	0.572	0.596	0.642	0.766	0.755	0.797	0.838
Second born	0.602	0.591	0.597	0.619	0.775	0.762	0.784	0.815
Third born		0.596	0.603	0.625		0.767	0.772	0.789
Fourth born			0.601	0.618			0.775	0.784
Fifth born				0.608				-0.065
N	713,389	399,240	111,503	31,809	713,389	399,240	111,503	31,809

Notes: This table reports the probability that the reading test score or the well-being measure is missing in grade 6, separately by children's birth order and family size. The upper panel includes only children in the cohorts where the outcome should be observed, while the lower panel includes all children in the gross sample.

Table A.3: Correlations across outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
	Reading	Mathematics	Well-being	Conscientiousness	Agreeableness	Emotional Stability
Reading	1					
Mathematics	0.623	1				
Well-being	0.128	0.142	1			
Conscientiousness	0.291	0.314	0.440	1		
Agreeableness	0.178	0.142	0.374	0.422	1	
Emotional Stability	0.100	0.117	0.714	0.408	0.317	1

Notes: This table reports the pairwise correlations for each of the main outcomes measured in 6th grade.

Table A.4: Effects of birth order on children's outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
	Reading	Mathematics	Well-being	Conscientiousness	Agreeableness	Emotional Stability
Second child	-0.149***	-0.079***	-0.118***	-0.137***	-0.073***	-0.038***
	(0.003)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)
Third child	-0.231***	-0.135***	-0.184***	-0.205***	-0.135***	-0.056***
	(0.007)	(0.009)	(0.011)	(0.011)	(0.011)	(0.011)
Fourth child	-0.251***	-0.157***	-0.271***	-0.273***	-0.201***	-0.115***
	(0.011)	(0.015)	(0.018)	(0.018)	(0.018)	(0.018)
Fifth child	-0.264***	-0.163***	-0.376***	-0.343***	-0.340***	-0.145***
	(0.019)	(0.025)	(0.031)	(0.030)	(0.031)	(0.031)
N	6,763,092	3,395,688	819,643	836,905	843,983	813,921

Notes: This table reports parameter estimates of the effect of birth order on the main child outcomes, controlling for maternal and paternal age at birth. Standard errors, clustered at the family/grade level, are reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.5: Effects of birth order by grade level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			Reading				Mathematics	
	2nd grade	4th grade	6th grade	8th grade	P-value	3rd grade	6th grade	P-value
Second child	-0.140***	-0.143***	-0.155***	-0.158***	0.049	-0.069***	-0.093***	0.000
	(0.006)	(0.006)	(0.006)	(0.007)		(0.007)	(0.006)	
Third child	-0.231***	-0.227***	-0.246***	-0.239***	0.688	-0.131***	-0.156***	0.003
	(0.013)	(0.012)	(0.013)	(0.014)		(0.013)	(0.013)	
Fourth child	-0.275***	-0.262***	-0.264***	-0.237***	0.228	-0.152***	-0.187***	0.021
	(0.022)	(0.020)	(0.020)	(0.022)		(0.022)	(0.020)	
Fifth child	-0.307***	-0.291***	-0.296***	-0.228***	0.141	-0.162***	-0.198***	0.199
	(0.037)	(0.035)	(0.035)	(0.038)		(0.037)	(0.034)	
N	333,611	332,589	322,717	287,054		334,190	321,877	

Notes: This table reports parameter estimates of the effect of birth order on the main child outcomes separately by grade level. Standard errors, clustered at the family level, are reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The p-values in separate columns indicate whether the effect of birth order differs significantly between the first and the last grade level.

Table A.6: Effects of birth order by grade level

	(1)	(2)	(3)	(4)	(5)	(6)
	Conscientiousness					
	4th grade	5th grade	6th grade	7th grade	8th grade	P-value
Second child	-0.143***	-0.124***	-0.141***	-0.149***	-0.129***	0.466
	(0.014)	(0.013)	(0.012)	(0.013)	(0.013)	
Third child	-0.221***	-0.175***	-0.205***	-0.228***	-0.198***	0.529
	(0.028)	(0.025)	(0.025)	(0.025)	(0.026)	
Fourth child	-0.286***	-0.240***	-0.303***	-0.301***	-0.258***	0.651
	(0.044)	(0.041)	(0.039)	(0.041)	(0.042)	
Fifth child	-0.424***	-0.266***	-0.345***	-0.366***	-0.377***	0.647
	(0.074)	(0.069)	(0.066)	(0.068)	(0.072)	
N	147,115	150,607	146,865	132,958	121,373	
	Agreeableness					
	4th grade	5th grade	6th grade	7th grade	8th grade	P-value
Second child	-0.092***	-0.060***	-0.078***	-0.068***	-0.082***	0.627
	(0.014)	(0.013)	(0.012)	(0.013)	(0.014)	
Third child	-0.175***	-0.100***	-0.136***	-0.114***	-0.154***	0.607
	(0.028)	(0.026)	(0.025)	(0.027)	(0.028)	
Fourth child	-0.238***	-0.151***	-0.193***	-0.176***	-0.235***	0.964
	(0.044)	(0.041)	(0.040)	(0.043)	(0.045)	
Fifth child	-0.397***	-0.270***	-0.285***	-0.296***	-0.426***	0.784
	(0.074)	(0.069)	(0.068)	(0.074)	(0.074)	
N	150,555	152,244	147,733	133,393	121,669	

Notes: This table reports parameter estimates of the effect of birth order on the main child outcomes separately by grade level. Standard errors, clustered at the family level, are reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The p-values in separate columns indicate whether the effect of birth order differs significantly between the first and the last grade level.

Table A.7: EFFECTS OF BIRTH ORDER BY GRADE LEVEL

	(1)	(2)	(3)	(4)	(5)	(6)
	Emotional Stability					
	4th grade	5th grade	6th grade	7th grade	8th grade	P-value
Second child	-0.018	-0.026**	-0.054***	-0.035***	-0.059***	0.033
	(0.013)	(0.013)	(0.013)	(0.013)	(0.014)	
Third child	-0.012	-0.044*	-0.084***	-0.056**	-0.102***	0.020
	(0.027)	(0.026)	(0.026)	(0.027)	(0.028)	
Fourth child	-0.023	-0.086**	-0.168***	-0.110**	-0.203***	0.004
	(0.044)	(0.042)	(0.041)	(0.043)	(0.045)	
Fifth child	-0.041	-0.098	-0.197***	-0.154**	-0.222***	0.088
	(0.074)	(0.070)	(0.069)	(0.073)	(0.076)	
N	142,651	145,644	142,648	129,114	118,362	
	Well-being					
	4th grade	5th grade	6th grade	7th grade	8th grade	P-value
Second child	-0.107***	-0.087***	-0.126***	-0.119***	-0.141***	0.071
	(0.013)	(0.012)	(0.013)	(0.013)	(0.014)	
Third child	-0.164***	-0.137***	-0.200***	-0.185***	-0.215***	0.189
	(0.026)	(0.025)	(0.026)	(0.027)	(0.028)	
Fourth child	-0.204***	-0.209***	-0.284***	-0.278***	-0.335***	0.036
	(0.043)	(0.041)	(0.041)	(0.044)	(0.046)	
Fifth child	-0.334***	-0.284***	-0.365***	-0.388***	-0.442***	0.306
	(0.073)	(0.070)	(0.067)	(0.074)	(0.076)	
N	143,656	147,028	143,635	129,979	119,194	

Notes: This table reports parameter estimates of the effect of birth order on the main child outcomes separately by grade level. Standard errors, clustered at the family level, are reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The p-values in separate columns indicate whether the effect of birth order differs significantly between the first and the last grade level.

Table A.8: Effects of birth order by family size

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	2 children	3 children	4 children	5 children	2 children	3 children	4 children	5 children
	Reading				Mathematics			
Second child	-0.151***	-0.147***	-0.123***	-0.092***	-0.091***	-0.073***	-0.057***	-0.033
	(0.006)	(0.006)	(0.013)	(0.027)	(0.007)	(0.007)	(0.014)	(0.029)
Third child		-0.260***	-0.234***	-0.129***		-0.155***	-0.118***	-0.054
		(0.013)	(0.021)	(0.037)		(0.014)	(0.022)	(0.041)
Fourth child			-0.327***	-0.201***			-0.173***	-0.107*
			(0.031)	(0.053)			(0.033)	(0.059)
Fifth child				-0.283***				-0.130*
				(0.071)				(0.078)
N	679,331	440,935	121,588	34,117	350,003	227,018	61,879	17,167
	Well-being				Conscientiousness			
Second child	-0.109***	-0.136***	-0.107***	-0.063*	-0.136***	-0.150***	-0.100***	-0.138***
	(0.008)	(0.009)	(0.017)	(0.035)	(0.008)	(0.008)	(0.016)	(0.035)
Third child		-0.222***	-0.158***	-0.150***		-0.240***	-0.173***	-0.183***
		(0.017)	(0.030)	(0.054)		(0.017)	(0.028)	(0.054)
Fourth child			-0.219***	-0.251***			-0.226***	-0.330***
			(0.044)	(0.078)			(0.042)	(0.077)
Fifth child				-0.315***				-0.403***
				(0.103)				(0.102)
N	392,653	271,807	75,574	21,536	401,631	277,559	77,308	22,068
	Agreeableness				Emotional Stability			
Second child	-0.080***	-0.071***	-0.077***	-0.103***	-0.044***	-0.055***	-0.012	0.004
	(0.008)	(0.009)	(0.017)	(0.036)	(0.008)	(0.009)	(0.017)	(0.035)
Third child		-0.135***	-0.136***	-0.166***		-0.092***	-0.005	0.009
		(0.018)	(0.030)	(0.056)		(0.017)	(0.029)	(0.054)
Fourth child			-0.188***	-0.251***			-0.042	-0.052
			(0.044)	(0.080)			(0.044)	(0.078)
Fifth child				-0.393***				-0.038
				(0.107)				(0.104)
N	405,091	279,632	78,280	22,468	389,970	269,988	74,738	21,285

Notes: This table reports parameter estimates of the effect of birth order on the main child outcomes separately by family size. Standard errors, clustered at the family level, are reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The p-values in separate columns indicate whether the effect of birth order differs significantly between the first and the last grade level.

Table A.9: Effects of birth order by type of work

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Part time	Full time	P-value	Part time	Full time	P-value	Part time	Full time	P-value
	Reading			Mathematics			Well-being		
Second child	-0.166***	-0.144***	0.006	-0.094***	-0.078***	0.152	-0.140***	-0.112***	0.037
	(0.007)	(0.004)		(0.010)	(0.005)		(0.012)	(0.006)	
Third child	-0.281***	-0.220***	0.000	-0.190***	-0.131***	0.010	-0.230***	-0.160***	0.010
	(0.014)	(0.008)		(0.020)	(0.011)		(0.024)	(0.013)	
Fourth child	-0.323***	-0.222***	0.000	-0.246***	-0.145***	0.007	-0.258***	-0.251***	0.880
	(0.024)	(0.013)		(0.033)	(0.018)		(0.041)	(0.022)	
Fifth child	-0.349***	-0.207***	0.006	-0.296***	-0.145***	0.033	-0.416***	-0.343***	0.424
	(0.046)	(0.023)		(0.063)	(0.032)		(0.082)	(0.040)	
N	383,826	1,378,953		201,197	696,626		335,580	1,110,207	
	Conscientiousness			Agreeableness			Emotional Stability		
Second child	-0.145***	-0.137***	0.551	-0.092***	-0.073***	0.157	-0.059***	-0.037***	0.101
	(0.012)	(0.006)		(0.012)	(0.006)		(0.012)	(0.006)	
Third child	-0.240***	-0.194***	0.092	-0.163***	-0.137***	0.341	-0.119***	-0.045***	0.007
	(0.024)	(0.013)		(0.024)	(0.013)		(0.024)	(0.013)	
Fourth child	-0.279***	-0.272***	0.877	-0.219***	-0.207***	0.796	-0.122***	-0.111***	0.813
	(0.040)	(0.021)		(0.041)	(0.022)		(0.041)	(0.022)	
Fifth child	-0.456***	-0.326***	0.146	-0.376***	-0.351***	0.786	-0.200**	-0.138***	0.517
	(0.081)	(0.038)		(0.083)	(0.040)		(0.087)	(0.040)	
N	339,421	1,123,684		340,876	1,128,665		334,457	1,106,280	

Notes: This table reports parameter estimates of the effect of birth order on the main child outcomes by type of work prior to the birth of the first child. Standard errors, clustered at the family/grade level, are reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.10: Effects of birth order by employment status

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Unemployed	Employed	P-value	Unemployed	Employed	P-value	Unemployed	Employed	P-value
	Reading			Mathematics			Well-being		
Second child	-0.137***	-0.152***	0.063	-0.069***	-0.087***	0.107	-0.112***	-0.119***	0.626
	(0.007)	(0.004)		(0.010)	(0.005)		(0.013)	(0.006)	
Third child	-0.220***	-0.240***	0.240	-0.115***	-0.158***	0.060	-0.171***	-0.177***	0.837
	(0.015)	(0.008)		(0.020)	(0.011)		(0.026)	(0.013)	
Fourth child	-0.248***	-0.243***	0.855	-0.117***	-0.189***	0.050	-0.217***	-0.266***	0.302
	(0.024)	(0.013)		(0.032)	(0.018)		(0.042)	(0.022)	
Fifth child	-0.283***	-0.220***	0.217	-0.104*	-0.207***	0.123	-0.391***	-0.357***	0.691
	(0.045)	(0.024)		(0.058)	(0.033)		(0.075)	(0.041)	
N	394,773	1,368,006		196,222	701,601		289,825	1,155,962	
	Conscientiousness			Agreeableness			Emotional Stability		
Second child	-0.128***	-0.142***	0.329	-0.084***	-0.077***	0.625	-0.035***	-0.044***	0.530
	(0.013)	(0.006)		(0.013)	(0.006)		(0.013)	(0.006)	
Third child	-0.185***	-0.212***	0.353	-0.153***	-0.140***	0.664	-0.059**	-0.064***	0.868
	(0.026)	(0.013)		(0.027)	(0.013)		(0.027)	(0.013)	
Fourth child	-0.207***	-0.296***	0.053	-0.194***	-0.219***	0.605	-0.066	-0.131***	0.171
	(0.041)	(0.021)		(0.043)	(0.022)		(0.042)	(0.022)	
Fifth child	-0.304***	-0.366***	0.444	-0.388***	-0.351***	0.665	-0.153**	-0.158***	0.953
	(0.071)	(0.039)		(0.075)	(0.041)		(0.074)	(0.041)	
N	293,867	1,169,238		295,271	1,174,270		288,983	1,151,754	

Notes: This table reports parameter estimates of the effect of birth order on the main child outcomes by employment status prior to the birth of the first child. Standard errors, clustered at the family/grade level, are reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.11: Effects of birth order on children's outcomes by sex

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Boys	Girls	P-value	Boys	Girls	P-value	Boys	Girls	P-value
	Reading			Mathematics			Well-being		
Second child	-0.139***	-0.174***	0.000	-0.081***	-0.089***	0.530	-0.118***	-0.142***	0.140
	(0.007)	(0.006)		(0.009)	(0.009)		(0.011)	(0.012)	
Third child	-0.228***	-0.283***	0.003	-0.160***	-0.158***	0.937	-0.167***	-0.238***	0.023
	(0.013)	(0.013)		(0.018)	(0.018)		(0.021)	(0.023)	
Fourth child	-0.262***	-0.341***	0.008	-0.201***	-0.201***	0.999	-0.265***	-0.353***	0.008
	(0.022)	(0.020)		(0.029)	(0.028)		(0.034)	(0.037)	
Fifth child	-0.315***	-0.378***	0.217	-0.243***	-0.189***	0.451	-0.380***	-0.450***	0.410
	(0.038)	(0.034)		(0.052)	(0.047)		(0.058)	(0.062)	
N	396,265	365,113		215,002	197,522		245,391	221,767	
	Conscientiousness			Agreeableness			Emotional Stability		
Second child	-0.133***	-0.155***	0.157	-0.082***	-0.088***	0.687	-0.031***	-0.068***	0.013
	(0.011)	(0.011)		(0.011)	(0.010)		(0.010)	(0.011)	
Third child	-0.196***	-0.245***	0.107	-0.136***	-0.161***	0.422	-0.049**	-0.104***	0.077
	(0.021)	(0.022)		(0.023)	(0.021)		(0.021)	(0.023)	
Fourth child	-0.286***	-0.361***	0.130	-0.185***	-0.263***	0.121	-0.106***	-0.181***	0.130
	(0.034)	(0.036)		(0.037)	(0.034)		(0.033)	(0.037)	
Fifth child	-0.356***	-0.360***	0.961	-0.332***	-0.439***	0.204	-0.188***	-0.172***	0.850
	(0.058)	(0.059)		(0.063)	(0.056)		(0.058)	(0.062)	
N	249,689	227,417		251,234	229,253		243,819	220,420	

Notes: This table reports parameter estimates of the effect of birth order on the main child outcomes by sex. Standard errors, clustered at the family/grade level, are reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.12: Effects of birth order by parental education

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	High educ.	Low educ.	P-value	High educ.	Low educ.	P-value	High educ.	Low educ.	P-value
	Reading			Mathematics			Well-being		
Second child	-0.165***	-0.136***	0.000	-0.091***	-0.075***	0.110	-0.117***	-0.127***	0.407
	(0.005)	(0.004)		(0.008)	(0.006)		(0.009)	(0.008)	
Third child	-0.264***	-0.221***	0.002	-0.171***	-0.134***	0.075	-0.161***	-0.194***	0.171
	(0.011)	(0.009)		(0.017)	(0.012)		(0.018)	(0.016)	
Fourth child	-0.332***	-0.232***	0.000	-0.215***	-0.156***	0.102	-0.231***	-0.254***	0.584
	(0.020)	(0.015)		(0.029)	(0.020)		(0.033)	(0.026)	
Fifth child	-0.423***	-0.231***	0.000	-0.308***	-0.151***	0.035	-0.134*	-0.413***	0.002
	(0.047)	(0.027)		(0.062)	(0.038)		(0.075)	(0.048)	
N	467,969	684,099		243,907	348,855		297,249	386,967	
	Conscientiousness			Agreeableness			Emotional Stability		
Second child	-0.159***	-0.136***	0.044	-0.078***	-0.089***	0.361	-0.044***	-0.052***	0.507
	(0.009)	(0.007)		(0.009)	(0.008)		(0.009)	(0.008)	
Third child	-0.240***	-0.198***	0.073	-0.137***	-0.162***	0.314	-0.072***	-0.074***	0.934
	(0.018)	(0.015)		(0.019)	(0.016)		(0.018)	(0.016)	
Fourth child	-0.326***	-0.251***	0.065	-0.221***	-0.221***	0.999	-0.114***	-0.115***	0.982
	(0.032)	(0.025)		(0.033)	(0.026)		(0.033)	(0.026)	
Fifth child	-0.386***	-0.368***	0.835	-0.329***	-0.385***	0.526	-0.087	-0.192***	0.250
	(0.073)	(0.046)		(0.074)	(0.048)		(0.077)	(0.049)	
N	303,049	396,279		304,630	400,250		295,509	384,255	

Notes: This table reports parameter estimates of the effect of birth order on the main child outcomes by parental education. Standard errors, clustered at the family/grade level, are reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.13: Effects of birth order by spacing

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	0-2 years	2+ years	P-value	0-2 years	2+ years	P-value	0-2 years	2+ years	P-value
	Reading			Mathematics			Well-being		
Second child	-0.134***	-0.177***	0.000	-0.064***	-0.112***	0.000	-0.110***	-0.130***	0.097
	(0.005)	(0.004)		(0.008)	(0.006)		(0.009)	(0.008)	
Third child	-0.285***	-0.280***	0.764	-0.191***	-0.190***	0.965	-0.177***	-0.193***	0.579
	(0.014)	(0.009)		(0.019)	(0.012)		(0.024)	(0.016)	
Fourth child	-0.333***	-0.315***	0.512	-0.228***	-0.247***	0.612	-0.283***	-0.256***	0.569
	(0.023)	(0.015)		(0.031)	(0.021)		(0.039)	(0.027)	
Fifth child	-0.368***	-0.333***	0.470	-0.285***	-0.255***	0.640	-0.376***	-0.405**	0.720
	(0.038)	(0.030)		(0.051)	(0.039)		(0.063)	(0.051)	
N	295,870	910,997		152,025	468,447		199,838	520,443	
	Conscientiousness			Agreeableness			Emotional Stability		
Second child	-0.131***	-0.171***	0.001	-0.062***	-0.088***	0.042	-0.031***	-0.062***	0.010
	(0.009)	(0.008)		(0.010)	(0.008)		(0.009)	(0.008)	
Third child	-0.228***	-0.261***	0.239	-0.112***	-0.160***	0.096	-0.058**	-0.096***	0.188
	(0.023)	(0.016)		(0.024)	(0.016)		(0.024)	(0.016)	
Fourth child	-0.327***	-0.344***	0.707	-0.169***	-0.233***	0.177	-0.109***	-0.165***	0.238
	(0.037)	(0.026)		(0.039)	(0.027)		(0.039)	(0.027)	
Fifth child	-0.444***	-0.420**	0.759	-0.285***	-0.410***	0.122	-0.153**	-0.235*	0.311
	(0.060)	(0.050)		(0.062)	(0.052)		(0.062)	(0.052)	
N	204,455	531,572		206,503	535,870		197,945	516,984	

Notes: This table reports parameter estimates of the effect of birth order on the main child outcomes by spacing between the first two children. Standard errors, clustered at the family/grade level, are reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.14: EFFECTS OF BIRTH ORDER ON CHILDREN'S HEALTH OUTCOMES

	(1)	(2)	(3)	(4)	(5)	(6)
	Birth weight		APGAR score		Maternal smoking	
Second child	172.6***	170.7***	0.092***	0.095***	-0.006***	-0.005***
	(1.903)	(1.962)	(0.003)	(0.003)	(0.001)	(0.001)
Third child	218.5***	214.969***	0.149***	0.153***	-0.004**	-0.003*
	(3.966)	(4.057)	(0.006)	(0.006)	(0.002)	(0.002)
Fourth child	236.9***	234.1***	0.190***	0.195***	-0.005	-0.003
	(6.482)	(6.568)	(0.010)	(0.011)	(0.003)	(0.003)
Fifth child	250.4***	249.7***	0.234***	0.238***	0.001	0.003
	(10.78)	(10.84)	(0.016)	(0.016)	(0.005)	(0.005)
Parental age controls		X		X		X
N	929,464		924,953		840,996	

Notes: This table reports parameter estimates of the effect of birth order on additional outcomes related to health at birth. Standard errors, clustered at the family level, are reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

1.2 On the Comparability of the Effects

In this paper, I argue that a comparison of the birth order effects (across different outcomes and over time) may be informative about the underlying skill formation process. However, this interpretation obviously hinges on the measures being comparable in the first place. In this section, I discuss potential threats to comparability and provide evidence suggesting that the scope of such threats is limited for the measures in question.

A first concern might be whether it makes sense to compare the effects on test scores to the effects on the survey measures. After all, the latter are considered "objective" while the latter are subjective. I do not have access to an objective measure of personality (and it is debatable whether such a measure exists). However, I do have access to subjective measures of achievement, as the well-being survey also contains questions about how well the child is doing in school. Specifically, I use the following items to construct a measure of subjective achievement: "What do your teachers think of your progress in school?", "Do you succeed in learning what you want in school?", "How often can you find a solution to problems, if you try hard enough?", "I do well in school, academically", and "If something is difficult for me during class, I can do something about it myself to move on". These five items, together with the three conscientiousness items, make up the factor that Niclasen et al. (2018) term "learning self-efficacy".

Although this outcome is not subject-specific, it can be compared to the achievement outcomes for reading and math. In Table A.15, I report how birth order affects subjective achievement, overall and by grade level. The birth order effects on subjective achievement are large and very similar in magnitude to the effects on reading test scores. This lends credit to the subjective measures. Thus, comparing only the subjective outcomes, we reach a similar conclusion: There are large birth order effects on well-being, conscientiousness, and (subjective) achievement, while there are smaller effects on agreeableness and emotional stability.

A second concern is measurement error. Test scores and survey responses are noisy proxies of the latent variables they are measuring. Measurement error in the dependent variable generally does not bias the estimates. However, because the outcomes do not have a natural scale, they are standardized, and if a certain trait has more measurement error, performing the standardization will reduce the variance of the trait more, which will make the effect size appear smaller relative to another trait with the same true variance but less measurement error. This point applies both across measures and with respect to the same measure over time. For example, if the measure of conscientiousness has more measurement error in grade 4 than in grade 8 (perhaps because younger children have a harder time

Table A.15: Effects of birth order on subjective achievement

	(1)	(2)	(3)	(4)	(5)	(6)
	Subjective Achievement					
	Overall	4th grade	5th grade	6th grade	7th grade	8th grade
Second child	-0.151***	-0.137***	-0.130***	-0.152***	-0.153***	-0.148***
	(0.007)	(0.014)	(0.013)	(0.013)	(0.013)	(0.014)
Third child	-0.229***	-0.229***	-0.197***	-0.221***	-0.224***	-0.234***
	(0.014)	(0.028)	(0.026)	(0.026)	(0.027)	(0.028)
Fourth child	-0.318***	-0.310***	-0.278***	-0.296***	-0.334***	-0.315***
	(0.022)	(0.045)	(0.042)	(0.041)	(0.043)	(0.045)
Fifth child	-0.390***	-0.388***	-0.312***	-0.304***	-0.400***	-0.431***
	(0.038)	(0.076)	(0.072)	(0.070)	(0.074)	(0.075)
N	746,051	125,056	131,980	131,116	117,826	110,281

Notes: This table reports parameter estimates of the effect of birth order on subjective achievement, overall and by grade level. Standard errors, clustered at the family level, are reported in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

answering the questions), this could lead to a pattern of increasing effect sizes over time.

To get a sense of how precisely the different outcomes are measured, I first consider the pairwise correlations between adjacent measures of the same outcome. Even with no measurement error, these correlations need not be equal to one because the underlying skill level may change from one year to the next. Specifically, the correlations across time reflect a combination of the reliability of the measures (the fraction of the total variance that is *not* due to measurement error), the self-productivity of the traits (the extent to which the trait in one period *causally* affects the trait in the following period), and the extent to which the trait is correlated with other variables that affect the growth in the trait (e.g., highly educated parents invest more in their children, and this increases the trait in a future period also *conditional* on the level of the trait in an earlier period).[30]

Table A.16 reports the pairwise correlations. As a starting point, the correlations can be interpreted as a lower bound on the reliability of the measures. Comparing across outcomes, the correlations suggest that measurement error might be more substantial for the survey measures, where the correlations are around 0.5, while the correlations for the test scores are higher despite these measurements being taken 2-3 years apart. This will, all else equal, make the effects appear smaller on the survey measures than on the test scores. On the other hand, the correlations appear stable over time, with only a weak indication of an increase.

[30]For more details, see Andersen et al. (2022) who provide a framework for separating the three components based on the same reading test scores.

Table A.16: CORRELATIONS ACROSS OUTCOMES

	(1)		(2)	(3)	(4)	(5)
	Test scores		Well-being	Conscientiousness	Agreeableness	Emotional Stability
Reading (grade 2-4)	0.677	Grade 4-5	0.502	0.510	0.431	0.507
Reading (grade 4-6)	0.743	Grade 5-6	0.509	0.534	0.465	0.524
Reading (grade 6-8)	0.714	Grade 6-7	0.461	0.531	0.471	0.506
Mathematics (grade 3-6)	0.623	Grade 7-8	0.510	0.546	0.474	0.526

Notes: This table reports the pairwise correlations for each of the main outcomes measured in 6th grade.

This suggests that changes in measurement error are unlikely to affect the comparison of the effects over time.

A different and perhaps superior approach is to use an instrumental variables strategy to obtain direct estimates of the reliability. First, an outcome is regressed on an earlier measure of the same outcome, for example, reading in grade 8 is regressed on reading in grade 6. As explained, this regression coefficient reflects a combination of the reliability, the self-productivity, and the omitted variable bias. Then, the same regression is run, but now the reading test score in grade 6 is instrumented by an even earlier score (grade 4). This approach removes the measurement error, and so the regression coefficient only reflects the self-productivity and the omitted variable bias. Under the assumption that the omitted variable bias is the same in grades 4 and 6, the relative change in the coefficient is simply the reliability ratio. This approach is more data-demanding though, as it requires three consecutive measures of the same outcome.[31] This means that I can only estimate the reliability of reading in grades 4 and 6. For mathematics, I can also estimate the reliability in grade 6 using a smaller sample because the math test was introduced in grade 8 for the most recent cohorts.

Table A.17 reports the estimated reliabilities. They largely confirm the picture from the raw correlations. If anything, the estimated reliability ratios are even more similar, both across outcomes and over time. The test scores still have higher reliabilities than the survey measures, but the difference is smaller. This suggests that the self-productivity is higher for reading and math skills than for the personality traits. Similarly, there is no clear trend across time for each different measure. Finally, I note that the reliability estimates for the reading test scores are similar to those obtained by Andersen et al. (2022) using a sample of

[31] One could also use different skills, e.g., one could use the reading score in grade 2 as an instrument for the math score in grade 3. However, because different skills may depend on unobserved characteristics to different extents, the assumption that the omitted variable bias is the same becomes less plausible.

Table A.17: Reliability estimates

	(1) Test scores		(2) Well-being	(3) Conscientiousness	(4) Agreeableness	(5) Emotional Stability
Reading (grade 4)	0.810	Grade 5	0.672	0.638	0.558	0.651
Reading (grade 6)	0.798	Grade 6	0.649	0.643	0.573	0.652
		Grade 7	0.640	0.650	0.575	0.640
Mathematics (grade 6)	0.755	Grade 8	0.686	0.670	0.575	0.669

Notes: This table reports the estimated reliability ratios for the measures in different grades. The estimates are obtained by dividing the OLS estimate by the IV estimate where the instrument is an earlier measure of the same outcome.

children taking the same tests twice (their estimates in grades 4 and 6 being 0.840 and 0.802), suggesting that my approach here is approximately valid. Overall, I conclude from this that the main results of the paper are unlikely to be affected by differences in measurement error to any significant extent. To the extent that measurement error does play a role, it should make me underestimate the magnitude of the effects on personality and well-being, relative to the effects on academic achievement.

1.3 Rational Explanations for Birth Order Effects on Investments

In this section, I discuss which circumstances may lead rational parents to produce systematic birth order effects.[32] Within a rational choice framework, there are two broad types of explanations as to why parental investments differ by birth order. First, parents may prefer to invest equally in all their children, but constraints prevent them from doing so. Second, regardless of whether parents are constrained or not, their preferences may lead them to allocate investments unequally. Below, I argue that different constraints can produce birth order effects in different directions and that estimation of birth order effects across different subgroups may be informative about the importance of such constraints. I then present an alternative argument, which entails that even unconstrained parents will produce birth order effects because they derive utility from interacting with their children and because of complementarity between time spent interacting with different children.

I start by considering one of the central arguments in Becker and Tomes (1986). In their framework, adult earnings are a function of ability, $Y_t = f(\theta_t)$. Parents may invest (I_{t-1}) to

[32] It is of course possible that parents do not behave rationally. For example, they may be inattentive to the fact that they devote more time and resources to earlier-born children. It would be interesting for future research to investigate to what extent parents are aware of their unequal allocation of resources.

increase their children's future earnings by affecting their ability:

$$\frac{\partial Y_t}{\partial I_{t-1}} = 1 + r_m(I_{t-1}, \theta_{t_1}) \tag{A.1}$$

where r_m is the marginal rate of return on parental investments, which depends on the level of investments and on the child's initial skills (which are a function of genetic and other endowments).

Assume first that parents can borrow at the market interest rate (r) to finance investments in their children. If parents are completely altruistic (or if parents' debt can become the obligation of their adult children), it is optimal for parents to invest in each child until $r_m = r$. Investments will then only differ between siblings because of initial skill differences due to (genetic) endowments, which do not differ systematically by birth order.

However, parents may be constrained in the extent to which they can borrow against their own or their children's future earnings. For simplicity, assume that parents are unable to borrow at all. Parents with sufficient wealth will still be able to invest optimally. Less wealthy parents, however, will have to lower their own consumption and/or leisure (if they increase their hours worked) to increase investments. In any case, these parents face a trade-off, and the level of investments will depend on the marginal utility of consumption and leisure relative to the utility derived from children's future earnings, meaning that investments will be sub-optimal from the child's perspective. In the context of birth order effects, this implies that investments will be lower when parents are more liquidity-constrained.

As most individuals accumulate wealth over the life course, investments should be lower for earlier-born children whose parents are younger. Hence, if liquidity constraints are important for birth order differences, they should work against the commonly observed pattern where earlier-born children do better. While there is some evidence that the birth order effect does reverse under severe poverty (De Haan et al., 2014), this cannot explain the birth order effects usually found in developed countries. Nevertheless, if liquidity constraints matter, one should expect that the birth order effect is smaller in families that are more likely to be liquidity-constrained.

So far, I have treated investments as being a matter of financial investments. However, a bulk of research has documented the importance of parental *time* investments (see, e.g., Cunha et al. (2006); Heckman and Mosso (2014)). To some extent, this distinction matters little in a theoretical framework. Whether parents invest their financial resources directly or utilize them to lower their hours worked (while maintaining the same level of consumption), which in turn allows them to spend more time with their children, is equivalent. But the distinction between time and money becomes relevant when parents are more constrained with respect to their ability to reallocate their time than with respect to reallocating their financial resources. Many jobs do not offer the flexibility to lower the number of hours worked. Hence, the choice that parents face, for example with the arrival of a second child, might be between keeping their current work intensity or lowering it to zero by quitting. In that case, parental time investments may be sub-optimal even if monetary investments are not. In the extreme case where parents are simply unable to adjust their work intensity, it is clear that this can cause the commonly observed birth order differences because the time constraint is more likely to be binding when more children are present, which will be disadvantageous to later-born siblings. If such constraints are important, we should expect that the birth order effect is smaller in families where the parents have flexibility in their hours worked, and in families where one or both parents work part-time or do not work at all.

While birth order effects might be an inefficiency resulting from parental constraints, another explanation is that parents' preferences lead them to invest differently in children by birth order even in the absence of constraints. In models of the parental investment decision, investments are a means to achieving certain outcomes (e.g., earnings of children as adults) that the parent cares about. Parents derive satisfaction from seeing their children succeed. While this is undeniable, it is hardly the only pleasure that parents obtain from their children. In the framework of Becker (1960), parental utility is a function of child quality, but parents also derive utility from the number of children. In other words, having children is in itself desirable for parents. I propose that an alternative way to rationalize birth order effects is to assume that investments are in themselves desirable for the parent. This is most obvious in the case of time investments, in which case it implies that parents enjoy spending (quality) time with their children. But even with financial investments, parents might derive utility directly because of warm-glow giving. This is an extension of the traditional models of parental investments. It may be that parents derive utility from investments *because* they perceive them to be important for their child's development, but it may also be that they enjoy the investments *beyond* their positive effect on the child.

In Appendix 1.4, I present an example of a formal model where the idea that parents derive utility directly from investments is incorporated into a skill formation framework. Letting parental utility depend directly on (time) investments is equivalent to saying that investing time in a child is a normal good, similar to leisure. With several children, investing in each represents different goods whose quantity may be increased by lowering consumption or leisure. Birth order effects will surface when investments in different children are complementary goods. If so, investing more in one child increases the utility of investing in another. This could happen if parents are inequality averse with respect to the allocation of their time in any given period.

On the one hand, parents will want to invest a lot when the returns to investments are highest. For example, there is ample evidence that investments are particularly important when children are very young and that the returns are decreasing in child age (Heckman, 2006; Heckman and Mosso, 2014). Say that two children are present in the home, one young and one old. If parents care only about returns to investments, they will invest the same amount of time in the young child as they invested in the older child when he was young. On the other hand, complementarity implies that investing more in the young child increases the utility of investing in the older child. Parents will not want to spend the vast majority of time with the youngest child, even if they should (from an efficiency perspective), because the opportunity cost in terms of the fear of neglecting the oldest child is increasing in time spent with the youngest child.

There is evidence that parental behavior is consistent with complementarity between investments in each child. In particular, Price (2008) documents that, although parents tend to spend more quality time with their children when they are young (consistent with efficiency in investments in skill formation), they also invest roughly the same amount of time in each child in the household at any given point in time, regardless of the age difference. This implies that parents behave according to almost perfect complementarity (or complete inequality aversion). If such preferences are the dominating cause of birth order effects, they should be observable among families regardless of whether they are constrained (with respect to money or time) or not.

1.4 A Preference-Based Model of Birth Order Effects

In this section, I develop a theoretical framework that can explain how birth order effects may originate from differences in parental investments. I model the effect of birth order on some skill, denoted by θ, of the child. I use the term "skill", but this term is interchangeable with any individual-specific pattern of cognition, emotion, or behavior that is relatively stable over time yet shaped by parental investments.

As in the seminal work by Cunha and Heckman (2007), I assume that skills of child i at age $t+1$ are a function of skills in the previous period, θ, investments made by parents, I, and some characteristics of the parents (e.g., their own skills), h. Investments are any actions taken by parents that foster child skill development.[33] Thus, the skill production

[33]In the following, I refer to investments in terms of time spent interacting directly with the child, although investments could also be financial or work in other indirect ways.

function is

$$\theta_{i,t+1} = f_t^{\theta}(\theta_{it}, I_{it}, h_i) \tag{A.2}$$

where skills are assumed to be increasing in each of the inputs. Furthermore, I assume that $\frac{\partial \theta_{i,t}}{\partial I_{i,t-s}} < \frac{\partial \theta_{i,t}}{\partial I_{i,t-s-1}}$ for all integers of s and t such that $t-s-1 \in (0,T)$, which implies that earlier investments are always more productive for the skill level in some later period. This may be due to higher returns to earlier investments and/or dynamic complementarity where early investments increase the returns to later investments (Cunha and Heckman, 2007; Cunha et al., 2010; Kautz et al., 2014). This is assumed to hold from the beginning of life and until some period T that could be referred to as the end of childhood (but might be much earlier than, say, age 18).

The object of interest in this paper is the birth order effect, which is the difference in some skill between the first-born and the later-born sibling measured at the same age, $\theta_{i,t}^{FB} - \theta_{j,t}^{LB}$, where i and j are children of the same parents. Because we are comparing siblings within the same family, we can abstract from the parental characteristics, h, which are assumed to be time-constant. Furthermore, skills in period 0 – before any child-specific investments are made, i.e., possibly at conception – are a function of parental characteristics and random (genetic) variation.[34] Hence, $E[\theta_{i,t}^{FB} - \theta_{j,t}^{LB}]$ depends solely on investments.

I assume that parents derive utility directly from investing in their children. This is a deviation from the traditional skill formation framework where utility stems from the skills that are produced by the investments (e.g., Cunha and Heckman (2007); Attanasio et al. (2020)). However, recent evidence suggests that parents care about the distribution of both inputs (e.g., parental investments) and outcomes (e.g., child earnings) (Berry et al., 2020). If parents care only about outcomes, and if they care equally about the outcomes of each of their children, rational parents should not systematically produce children where the first-borns end up with the highest skill levels unless first-borns are inherently different.For example, in the models by Behrman et al. (1982) and Becker and Tomes (1986), differences between siblings may arise despite inequality aversion through differences in genetic endowments. However, as full siblings inherit their endowments from the same pool of parental genes, this mechanism does not lead to birth order differences either.

Arguably the simplest – and possibly also the most realistic – modeling solution is to assume that parents *like* to spend at least some time with their children regardless of the outcome of such interactions (in terms of skills produced).[35] I assume that the utility of the

[34] At each location in the DNA, the child inherits one (random) genetic variant from each parent.

[35] If the reader prefers to think of this utility as not stemming from the parent enjoying the interaction

parent can be described by

$$U_p = \prod_{t=0}^{T+\delta_{1,n}} \Big(\Big(\sum_{\substack{i\in\{1,..,n\}\\ \delta_{1,i}\leq t\leq T+\delta_{1,i}}} (\beta_{s(i,t)} I_{it})^{-\rho}\Big)^{-\frac{1}{\rho}}\Big)^{\bar{\beta}_t \frac{\rho}{\rho+1}} - \alpha \sum_{t=0}^{T+\delta_{1,n}} \sum_{\substack{i\in\{1,..,n\}\\ \delta_{1,i}\leq t\leq T+\delta_{1,i}}} I_{it} \tag{A.3}$$

i.e., as a function of parental investments (I_{it}) in child i at time t, which are constrained in each period to $\sum_i^n I_{it} \leq 1$. $\delta_{1,i}$ denotes the age difference between the first-born child and child i. Hence, the condition $\delta_{1,i} \leq t \leq T + \delta_{1,i}$ ensures that only children who are born and who are still in childhood (which lasts T periods) in period t enter into the investment decision. In the periods where multiple children are present, utility is described by a CES-type function (the first sum in Equation A.3) that allows for aversion to inequality in investments at a given point in time. Total utility then depends on the product of the period-specific utilities over all periods where children are present ($T + \delta_{1,n}$).[36] The last part of the utility function captures the opportunity cost of investing (e.g., not working), which is assumed to be linear (by some parameter, α) in the sum of investments in all children over all periods where they are present.[37]

The $\beta_{s(i,t)}$'s are parameters capturing how the valuation of investments changes depending on the age, s, of child i at time t (with $\bar{\beta}_t$ being the average of these parameters among the children who are present in the household at time t). $\{\beta_{s(i,t)}\}_{s=0}^{T}$ is assumed to be a decreasing sequence, reflecting that younger children have a greater demand for parental time investments, and not spending time with a younger child is therefore associated with greater disutility for the parent. Another interpretation is that the $\beta_{s(i,t)}$s reflect that the parent knows that investments have different productivity at different stages of childhood, which would make them analogous to the *skill multiplier* parameter in Cunha and Heckman (2007).

ρ captures the degree of aversion to dividing investments unequally at any given point in

per se but rather from the parent having internalized the idea that the interactions benefit their children, now or in the future, this is equally consistent with the model that follows. For example, I_{it} could simply be replaced by the utility of the child which in turn would be determined by investments. But importantly, the child would derive utility not just in the final period based on the sum of investments, but rather from the investments in each period, and the parent/child might therefore care about the distribution of investments.

[36] An implicit assumption is thus that the parent has perfect foresight, e.g., knows the total number of children in advance.

[37] The opportunity cost could consist of both foregone consumption and leisure. In either case, the parent values the total amount of consumption/leisure over all periods with children in the household, regardless of how it is distributed across time. If we think of it in consumption terms, this corresponds to a world with perfect credit markets where the parent can borrow against future income at no interest rate (a positive interest rate would add an incentive to work more and invest less in the earlier periods, which would work against the birth order effect).

time. As $\rho \to 0$, the function in the parenthesis approaches a Cobb-Douglas utility function, which entails that the optimal level of investments is determined by the $\beta_{s(i,t)}$-parameters and hence only depends on the age of the child and not the birth order. As $\rho \to \infty$, the function approaches a Rawlsian welfare function where investments are perfect complements and are hence divided equally between all children that are present in that period, i.e., there is complete inequality aversion.[38] In that case, earlier-born children are at an advantage because they share investments with fewer siblings during early childhood (in particular, first-born siblings do not have to share investments until the arrival of the second-born child).

As an illustrative example, consider the case of a parent with two children, born one period apart, in a world where childhood lasts for two periods ($n = 2, T = 1, \delta_{1,2} = 1$). Thus, in period $t = 0$, only the first-born sibling is present and is at the beginning of childhood; in period $t = 1$, both siblings are present, the second-born being in the early stage of childhood and the first-born being in the late stage of childhood; finally, in period $t = 2$, the second-born sibling is at the end of childhood whereas the first-born sibling is no longer a child and hence does not enter into the investment decision. With $\rho \to 0$, utility of the parent is given by

$$U_p = (I_{1,0}I_{2,1})^{\beta_0}(I_{1,1}I_{2,2})^{\beta_1} - \alpha(I_{1,0} + I_{1,1} + I_{2,1} + I_{2,2}) \tag{A.4}$$

and it follows that maximizing utility entails setting $I_{1,0} = I_{2,1}$ and $I_{1,1} = I_{2,2}$, i.e., to invest the same in each child's first (and second) period of life. Investments are still more substantial in the first period of life, but they are so to the same extent for both siblings (with $\frac{I_{i,t}}{I_{i,t+1}} = \frac{\beta_0}{\beta_1}$, see appendix for details); hence, no birth order effects arise.

Whereas with $\rho \to \infty$, utility of the parent becomes

$$U_p = I_{1,0}^{\beta_0} \min(I_{1,1}, I_{2,1})^{\frac{1}{2}(\beta_0+\beta_1)} I_{2,2}^{\beta_1} - \alpha(I_{1,0} + I_{1,1} + I_{2,1} + I_{2,2}) \tag{A.5}$$

Hence, utility is maximized by instead setting $I_{1,1} = I_{2,1}$, that is, to invest the same in both children in period $t = 1$ (where the first-born is in the first period of childhood and the second-born is in the last period of childhood). Conversely, the first-born will receive more investments in the first period of childhood than the second-born will in the last period of childhood (as before with $\frac{I_{1,0}}{I_{2,2}} = \frac{\beta_0}{\beta_1}$). Thus, overall investments are higher for the first-born, leading to a birth order effect. Of course, any intermediate value of ρ

[38] The other extreme case of perfect substitutes is represented by $\rho = -1$. Here, utility depends only on the sum of the investments times the $\beta_{s(i,t)}$-parameters, and the parent would hence only invest in the youngest child present.

will lead to an intermediate version of these extreme cases. In the following, I assume that $\rho >> 0$, i.e., parents are sufficiently inequality averse such that meaningful differences in investments arise. This is consistent with Price (2008) who finds support for almost full temporal inequality aversion ($\rho = \infty$), as well as with Pavan (2016) and Lehmann et al. (2018) who also find considerable differences in investments that are able to explain most of the birth order differences observed for cognitive ability.

The model leads to three predictions, which I now describe in turn. First, unlike earlier models of the allocation of parental investments (Behrman et al., 1982; Becker and Tomes, 1986; Bagger et al., 2021), my framework unambiguously predicts a birth order effect where earlier-born children have higher skills at any given age. Because parents are compelled to adjust their investments at least partly towards equality among all children present at a given point in time, earlier-born siblings will tend to receive more parental investments in total, and in particular, more parental investments during early childhood. In particular, first-borns are always at an advantage because they do not have to share investments with siblings until the arrival of the second-born. In general, second-borns are also at an advantage relative to later-borns because the later-born sibling will be sharing parental investments with even more siblings in the early stages of life where investments are most productive.

The second prediction is that for siblings born shortly after each other, the birth order effect should be smaller than if the spacing between them is relatively large. For example, in a two-child family where the siblings are born just one year apart, the first-born child only has the advantage of being the only child in the first period. The second-born child also has the advantage of being the only child in one period, but this will happen in the last period where investments are least productive (and parents are less compelled to invest heavily). Hence, even small differences in spacing may lead to birth order effects. But if the spacing is larger, the first-born advantage extends to more periods, and hence, the birth-order effect should increase in spacing.[39]

The final prediction relates to family size and the quantity-quality trade-off. All else equal, more siblings reduce the amount that can be invested in each child, leading to lower

[39]For very large spacing, this relationship reverses. In a two-child family, the first-born child has the advantage of being the only child present for the first $\delta_{1,2}$ periods of childhood, whereas the second-born child has the advantage of being the only child present for the last $T - \delta_{1,2}$ periods of childhood. Hence, if $\delta_{1,2}$ increases beyond $\delta_{1,2} = \frac{T}{2}$, the additional separation starts favoring the second-born because the additional period where she is the only child falls in an earlier period of childhood than it does for the first-born. In the extreme case where the second-born sibling is at least T years younger than the first-born child, both children will in practice grow up as only children and we should not expect birth order effects. Thus, all else equal, this predicts an inverse-U relation between the birth order effect and the spacing. However, by far the majority of siblings will probably be born in relatively close succession such that they are at a point where the birth order effect is increasing in spacing.

skills among all siblings. But the previous siblings will be differentially affected, and hence the family size effect interacts with the birth order effect. Specifically, an additional (say, a third) child should increase the skill gap between two earlier-born children because investments in the first-born sibling are lowered in fewer periods (and at an older age) than are investments in the second-born sibling. Hence, an exogenous increase in family size at a given point in time should increase the birth order effect among siblings born before this time.