The birth order paradox: sibling differences in educational attainment

THE BIRTH ORDER PARADOX:
SIBLING DIFFERENCES IN EDUCATIONAL ATTAINMENT

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ABSTRACT

This study uses population register data to examine the relationship between birth order and educational attainment in Sweden, and demonstrates that while the net effect of birth order on educational attainment is negative, later-born children often spend longer in education. The explanation for this finding is due to educational expansion in Sweden in the 20th century, which outweighs the negative causal effect of birth order for the affected cohorts. This is particularly true for women due to the fact that the rate of increasing educational enrolment has been greater for women than for men. These results also show that later-borns in large families particularly benefit from educational expansion due to the longer average birth interval between the first and last child in large families, meaning that the supply of educational opportunities increased to a greater extent in the intervening period. However, in periods where education is not expanding, later-born siblings continue to fare worse than first-borns.

INTRODUCTION

The influence of birth order on a range of later life outcomes, including educational achievement, intelligence, and personality, has been the subject of scholarly interest for over a century (Galton, 1874; Gini, 1915; Blau and Duncan, 1967; Ernst and Angst, 1983; Sulloway, 1996; Black et al., 2005). Partly because of the long history of research on this topic, the study of birth order has been approached from every conceivable research angle, from psychiatrist case studies, to qualitative interviews, to quantitative analysis of large data (Toman, 1961; Conley, 2004; Black et al., 2005). Much of the research on this topic has been criticised for a lack of methodological care and rigour (Schooler, 1972; Ernst and Angst, 1983; Rodgers, 2001). Literally hundreds of studies have been conducted on the relationship between birth order and almost any conceivable outcome, with a lack of consensus on the correct study design leading to wide variation in the reported results (Ernst and Angst, 1983), from first-borns performing best, to last-borns performing best (Blake, 1989a), to middle-borns performing worst (Blau and Duncan, 1967; Conley, 2004), while others have concluded that birth order has no consistent influence on attainment (Ernst and Angst, 1983; Steelman et al., 2002).

Despite this history, the past decade has seen econometricians converge upon the conclusion that the net effect of birth order on educational attainment is negative. This more recent research has attempted to isolate the net effect of birth order by using a fixed effects study design, comparing siblings to one another within the same family (e.g. Black et al., 2005). Because these siblings share the same biological parents and the same family environment and background, after adjusting for variables that are not constant amongst the siblings, primarily birth year, it has been argued that the causal

relationship is identified. Research using these sibling comparisons has consistently found that later-born siblings have lower educational attainment than first-borns across Europe (Black et al., 2005; Kalmijn and Kraaykamp, 2005; Härkönen, 2014; Barclay, 2015a), as well as in the United States (Kantarevic and Mechoulan, 2006). Where the data has allowed this question to be examined in more detail, it has been shown that this negative monotonic relationship exists across the most common family sizes, and that the last-borns in large families particularly fare the worst (Black et al., 2005; Barclay, 2015a).

Although this recent body of literature has consistently shown that later-borns have worse educational outcomes than first-borns, these studies have neglected to consider the role of macro-level trends in educational expansion and how that shapes relative educational attainment between siblings. Within a family, there is a mechanical relationship between birth order and birth year, with later-born siblings always born into a later calendar year. In a context where there is a secular increase in high school completion and tertiary enrolment, those born into a later birth year will be more likely to achieve greater educational attainment and to benefit from that higher level of educational attainment due to the increase in the supply of educational opportunities. The purpose of this study is to show that although recent research has shown that the net effect of birth order on educational attainment is negative, due to educational expansion across Western Europe and the United States since the end of the second world war, later-born siblings exposed to periods of educational expansion have, on average, spent longer in the educational system than first- and other earlier-born siblings.

I illustrate this pattern using Swedish population register data, but due to educational expansion across Western Europe and the United States since the end of the second world war (Breen and Jonsson, 2007; Breen et al., 2009; Breen, 2010), the point is likely to generalize to other contexts where the supply of educational opportunities has also been expanding. While identifying causal effects is an important enterprise, I argue that it is equally important to simultaneously consider the broader descriptive picture. Increased educational attainment is likely to have a substantive impact on the lives of later-borns, due to the beneficial effects of education on opportunities for social mobility (Breen, 2010), earnings (OECD, 2013), and health (Lager and Torssander, 2012). Furthermore, I contend that improving environmental conditions over time may explain why some researchers examining birth order effects during periods of educational expansion who have not applied a sibling comparison design have found that later-born siblings tend to have more favourable outcomes than first-borns.

Birth Order and Educational Attainment: Mechanisms and Empirical Evidence

Two main theories have been developed to explain why later-borns should have lower educational attainment, which are the confluence hypothesis (Zajonc, 1976) and the resource dilution hypothesis (Blake, 1981). The confluence hypothesis argues that the average degree of intellectual stimulation within the household influences the cognitive development of children. Until the birth of the second child, a first-born will interact exclusively with his or her parents, and this degree of cognitive stimulation is likely to be beneficial for development. A second-born, however, interacts not only with the parents, but also with the older sibling, who is much less cognitively stimulating, and the average degree of stimulation decreases as more children enter the household. The

confluence hypothesis also makes a case for the importance of sibling peer effects in the cognitive development process. In the long-run older siblings are thought to benefit intellectually from having to tutor younger siblings, while the latter suffer as the opportunity to solve problems for themselves is pre-empted (Zajonc et al., 1979; Blake, 1989b). This disadvantage is particularly exaggerated amongst last-born children, who have no younger sibling to tutor.

The resource dilution hypothesis also states that later-borns should be disadvantaged relative to first-borns. Until the birth of later siblings, the first child benefits from complete access to parental attention and investment. Although few children suffer from material deprivation in Sweden, and parents typically accumulate greater socioeconomic resources as they age, a resource that is certainly finite is parental time. Later-born children are likely to receive less attention from the parents than a first-born would during the first years of life, as the parents must also attend to the older children. This could lead to birth order differences in exposure to language and reading opportunities at early ages, which may in turn affect language development and vocabulary expansion (Sénéchal et al., 1998; Sénéchal and LeFevre, 2002; Weisleder and Fernald, 2013). Although a last-born child will have exclusive access to parental resources at older ages, after the older siblings have left the home, the benefits of parental investment and language exposure at early ages are likely to have cumulative effects on subsequent academic performance (Stanovich, 1986), and a growing body of evidence suggest that there are diminishing returns to investment on cognitive development with increasing age (Reynolds et al., 2003; Cunha et al., 2006; Heckman, 2006; 2007).

Although the resource dilution hypothesis suggests that resource dilution should be a function of birth order and birth spacing, recent research using a sibling fixed effects design to study how the length of the birth interval before and after the index person affects long-term educational attainment suggests that the net effect of birth spacing itself is negligible, while the commonly observed pattern that later-borns achieve lower attainment that earlier-born siblings persists (Barclay and Kolk, 2017). Since the length of birth intervals should be at least partially capturing the amount of time spent with parents, this finding suggests that the inequitable resource distribution by birth order may not only be a function of the number of children and time between births. Another possibility is that parents treat children differently by birth order in ways that are not necessarily conditional on the number of children or the spacing between births. Although reports that parents spend more time with first-borns (Price, 2008), are consistent with the resource dilution hypothesis, studies also indicate that parents are more likely to restrict television watching for first-borns in comparison to later-borns (Holtz and Pantano, 2015), and that parents are more likely to punish first-borns than later-borns if they have poor grades in school (Hotz and Pantano, 2015). Furthermore, the rates of breastfeeding decrease with higher parity, mothers are less likely to seek prenatal care for later-born children (Buckles and Kolka, 2014), and in Sweden parents take more parental leave time for first-borns than they do for later-born children (Sundström and Duvander, 2002). It is possible that at higher parities parents behave differently because of a fatigue effect, where ideals about the right way to raise a child are more likely to bend in response to conflicting demands. Higher parity childbearing is also likely to be accompanied by a decrease in the novelty of the experience, and a decrease in anxiety about the childrearing process.

These studies suggest that, even in a country such as Sweden where access to education is free at all levels, relative differences between siblings could be produced by differences in early life investment and parental treatment by birth order. Indeed, in a context where structural educational opportunities are held constant, first-borns consistently have greater educational attainment than later-borns. However, in a context where those born into a later birth year have systematically greater opportunities for educational progression because of an increase in the supply of educational opportunities, these secular trends may counterbalance or even outweigh the negative effect of birth order on attainment.

The Swedish Education System and Educational Expansion

Education in Sweden is state funded at all levels, and tertiary education is free for Swedish and European Union citizens (Halldén, 2008; Högskoleverket, 2012). To give an idea of the relative burden that university tuition fees place on students in different countries, average tuition fees as a percentage of GDP per capita in 2006/07 were 2.7% in Norway, 0.0% in Sweden, 3.1% in the Netherlands, 1.3% in Germany, and 25.5% in the United States (Willemse and De Beer, 2012). Students in tertiary education are eligible for financial support from the Swedish state for living costs in the form of study grants and student loans with low interest rates (Högskoleverket, 2012), minimising the need for reliance on family resources for maintenance. This has meant that family resources in Sweden are not crucial for the transition to tertiary education in the same way that they are in other contexts, such as the United States. This does not mean that there is no socioeconomic stratification in educational attainment in Sweden, but that the choice to continue in the education system is not affected by the direct costs of

tuition. Nevertheless, indirect costs, such as foregone earnings, are likely to influence the decision-making processes of high and low socioeconomic status individuals to differing extents.

The Swedish education system today is divided into three sections: grundskolan, which is 9 years of compulsory schooling, gymnasium, which is three additional years of upper secondary education, and tertiary education (Halldén, 2008). The tertiary education system in Sweden is consistent with the Bologna accords, and has degrees at the Bachelors (3-years undergraduate), Magister (1-year taught postgraduate), Masters (2-year taught postgraduate), Licentiate (2-years of postgraduate research), and Doctoral (4-years of postgraduate research) levels (Halldén, 2008). The vocational tertiary education system (Högre yrkesutbildning) consists of practical, technical, and occupation-specific tertiary training programs (Halldén, 2008). Although I discuss the data in greater detail in the next section, the cohorts that I analyse in this study were born 1960 to 1982. This means that they will have been 16 and in secondary school in Sweden between approximately 1976 and 1998. This was a period of substantial change in the Swedish educational system, as is summarised by Halldén (2008). In 1965 and 1971 gymnasium was reorganised into three tracks: the first prepared students for university, the second was a two-year continuation program, and the third was two years of vocational training (Erikson and Jonsson, 1996a). While the first track was the most direct route to a typical university education, it was not impossible to apply to university from either of the latter two tracks (Halldén, 2008). Before 1971, these three educational tracks were split into separate schools, and applying to university directly from either of the less traditionally academic tracks was much more difficult (Halldén, 2008).

A major motivation for reforming upper secondary education in Sweden was to increase social fluidity, meaning to reduce the strength of the relationship between the class of origin and class of destination (Erikson and Jonsson, 1996a). The aforementioned reforms led to a large increase in the proportion who made the transition to upper secondary education (Erikson and Jonsson, 1996b; Rudolphi, 2013). Indeed, this was part of a broad package of expansion in the supply of educational opportunities in Sweden in the post-war period, which also included an expansion of adult education, and changes to the tertiary education system, including the founding of a significant number of new universities and university colleges (Erikson and Jonsson, 1996a). Although there have been some fluctuations in tertiary education enrolment, between the 1960s and 2000s enrolment has increased substantially (Breen et al., 2009), just as it has in many other countries in Western Europe and the United States (Breen and Jonsson, 2007; Breen et al., 2009). Today, approximately 33% of the Swedish population has undergone post-secondary education, which is higher than the OECD average (Högskoleverket, 2012). This increase in the supply of educational opportunities at the upper-secondary and tertiary levels has clearly benefited individuals born during those periods, which has implications for patterns of educational attainment by birth order.

While educational expansion in the 20th century will have, on average, benefited later-born children over earlier-borns from the same family during those periods, the degree to which individuals were able to take advantage of this environmental improvement will have varied by gender. The increase in educational enrolment with successive cohorts has been greater for women than men in Sweden, and women are now less likely than men to have only primary education, and more likely than men to have a

tertiary education (Breen et al., 2010). The increasing educational attainment of women over successive cohorts has been observed across Europe and the United States (Buchmann, DiPrete and McDaniel, 2008). The explanations for women first catching up and then overtaking men in educational attainment are multifold. From the 1960s multiple processes, including improvements in gender equality as well as the emergence of oral contraceptives, gradually eroded traditional gender roles, opened up greater educational opportunities and therefore also labour market opportunities, and provided women with the agency to defer marriage and childbearing until a point at which they were more willing to embrace those life course stages (Gelb, 1989; Goldin and Katz, 2002). Increasing gender equalization in the labour market provided young women with increasingly greater incentives to pursue careers due to improving earnings returns to education, as well as the increasing possibilities of securing high status labour market positions. Furthermore, structural labour market conditions as well as increasing income inequality mean that the costs of foregoing tertiary education are greater today than ever before (Taylor et al., 2014), and since girls clearly outperform boys in school (Buchmann, DiPrete and McDaniel, 2008), which increases access to tertiary education, fewer and fewer women choose to ignore the potential advantages of continuing their educational careers.

Given that the benefit of being born later primary extends from environmental improvements in the intervening period, it is also valuable to consider the role of birth intervals. In this study I will show that the increase in educational enrolment can have a large impact even in small families with only two children when the birth interval is long enough. Since research indicates that the length of birth intervals does not itself have any meaningful effect on long-term educational attainment in Sweden (Barclay and Kolk,

2017), the mechanism by which longer birth intervals should benefit later-born siblings is through increases in the supply of educational opportunities, or educational expansion, in the intervening period. For example, second-born children who are born many years after the first child benefit a great deal from educational expansion, though this is particularly clear for women.

DATA AND METHODS

Data

This study is based upon data from the full Swedish administrative population registers. Although the Swedish multigenerational register allows for intergenerational linkages from cohorts born in 1932 and later, I examine men and women in cohorts born from 1960 to 1982. The reason for using these particular cohorts is that the highest quality data on education is available from 1990 to 2012. Using these cohorts therefore allows one to look at the educational attainment of these individuals in the year that they turn 30 with a high degree of accuracy. The total number of individuals born in Sweden in these cohorts was 2,435,773. However, the final population used for the analyses is 1,578,667, of whom 766,266 are women, and 812,441 are men. The reason for this is that it is necessary to apply several exclusion criteria, which are summarised in Table 1. I define a sibling group as a group of children who share the same biological mother and father. I restrict the population used for the analysis to those sibling groups where all the children are born in Sweden so that information about birth order and the size of the sibling group is known with a high degree of accuracy. Although I focus on siblings born between 1960 and 1982, the calculation of birth order and other family characteristics

276 are based on the complete family history, not just on births that occur within this cohort
277 window. I also exclude sibling groups that include a multiple birth such as twins, as the
278 meaning of birth order is much less clear in these families. As will be outlined in more
279 detail below, the statistical approach used in this study is sibling fixed effects, meaning a
280 within-family comparison. As this type of analysis compares siblings to one another
281 within the same sibling group, it is necessary that there are at least two individuals in
282 the data for each sibling group. This means that individuals who were only-children are
283 not included in the analyses. This study also focuses on sibling groups of two to six
284 children, as sibling groups with more than six children are relatively rare in Sweden.
285
286 *** Table 1 – Approximately Here ***
287
288 Given that the cohorts that I examine in this study were born 1960 to 1982, it is
289 important to consider whether the increased prevalence of blended families introduces
290 error into the measurement of the birth order variable. Amongst those born in the
291 1960s in Sweden, 23% of individuals have at least one half-sibling, and for those born in
292 the 1970s and 1980s the corresponding figure is 25% and 30%, respectively (Thomson,
293 2014). Furthermore, these figures do not account for step-siblings. Previous studies
294 have indicated that it is social order within the sibling group rather than biological birth
295 order that explains birth order patterns (Kristensen and Bjerkedal, 2007; Barclay,
296 2015a). Using register data to accurately capture the experience of social birth order is
297 difficult, and this is particularly true in blended families. One way of approaching this
298 issue is to examine the research question in this study only amongst sibling groups
299 where neither of the parents have any children with a third person. In these cases, the
300 experience of social birth order is likely to conform more closely to the measure of

biological birth order. Although the main results presented in this study will be based upon the full population without taking into account half-siblings, I also conduct analyses based upon sibling groups without half-siblings as a robustness check.

Outcome Variable

The outcome variable in this study is years of education achieved by age 30. This measure is based upon the number of years that correspond to the specific level of education achieved by age 30, and may not in all cases reflect that actual number of years that an individual spent in the educational system. The variable for highest educational level and the corresponding years of education required to reach that level come from the Swedish education registers and Statistics Sweden (Halldén, 2008; Statistics Sweden, 2000). I also estimate models using entry into tertiary education by age 30 as a robustness check.

Statistical Analyses

The estimation strategy used for analysing educational attainment is fixed effects linear regression, with and without a control for birth year:

(1) $y_{ij} = \alpha_j + \beta_1 \text{BIRTHORDER} + \varepsilon_{ij}$

(2) $y_{ij} = \alpha_j + \beta_1 \text{BIRTHORDER} + \beta_2 \text{BIRTHYEAR} + \varepsilon_{ij}$

where y_{ij} is the measure of educational attainment at age 30 for individual i in sibling group j. Both models 1 and 2 apply the unobserved sibling fixed effect α_j, and ε_{ij} is the error term. $BIRTHORDER_{ij}$ is the birth order of individual i in sibling group j, while $BIRTHYEAR_{ij}$ is the year of birth of individual i in sibling group j. Although birth order and birth year are correlated within the family, this correlation is not high enough for concerns about collinearity in the model, particularly given the large number of observations available for analysis. The key coefficient of interest is β_1 as that is the estimate for birth order.

These analyses compare the years of education attained by age 30 of siblings who share the same biological mother and father to one another. The estimation of the standard errors allows for correlation of errors within each sibling group. These fixed effects models produce a within-family comparison, and inherently adjust for both observed and non-observed intra-family characteristics that remain constant, thereby minimizing residual confounding from factors that are related to fertility behaviour of the parents as well as long-term educational outcomes amongst the children, such as parental socioeconomic status. In contrast to a between-family comparison approach, this allows for the isolation of the effect of birth order on educational attainment independent of shared family environment characteristics that are also important for educational outcomes. Furthermore, only a within-family comparison can reveal the positive benefits of being a later-born, as a mechanical relationship between birth order and birth year can only be found within families.

To understand the relationship between birth order and educational attainment, and how that varies according to period changes in the supply of educational opportunities, I

estimate three groups of models. The first set of models examines the effect of birth order on educational attainment amongst cohorts who did, or did not, benefit from educational expansion. The second set of models examines birth order in two child sibling groups, stratified by gender and the length of the birth interval between the two siblings. Twenty separate analyses were run, by birth interval length and sex: 10 for two-child sibling groups where both children were boys, and 10 for two-child sibling groups where both children were girls. The third set of models examines the effect of birth order on educational attainment stratified by sibling group size and gender. Since there must be at least two children in the sibling group to estimate the fixed effects models, these models stratified by sibling group size and gender are based on sibling groups where the total number of siblings (male and female), is equal to *N*, and the where the number of siblings of the focal gender is greater than or equal to two.

RESULTS

Descriptives

As can be seen in Table 2, the mean years of education achieved by age 30 by women for the individuals born 1960 to 1982 was 12.9 years, and for men 12.5 years. For women the mean years of education achieved by age 30 across families decreases with rising birth order and increasing set size, and also increases by birth year. Table 2 shows that mean years of education for women is greatest, at 13.4, for women whose mothers were aged 30-34 at the time of their birth, and it is lower for women born to mothers who were older and younger than that at the time of birth. It is particularly low for those born to teenage mothers. For men the patterns in the summary statistics for years of

education by age 30 are generally very similar to those seen for women

*** Table 2 – Approximately Here ***

*** Figure 1 – Approximately Here ***

Figure 1 shows the distribution of birth spacing, and the mean years of education by birth interval length and sex. As can be seen the most common interval length in Sweden amongst these birth cohorts was 25 to 36 months. Mean years of education varies by birth interval length, where those born either side of a very short birth interval of 0 to 12 months have a lower mean than those born either side of the most common birth interval length. Figure 1 also shows that children born either side of a very long birth interval have a lower mean than those born either side of the most common birth interval lengths.

Fixed Effects Models

Analyses by Cohort Group

To examine whether educational expansion had a counterbalancing effect against the negative effects of birth order, I first examine whether the birth order effect on educational attainment varies amongst cohorts who were, or were not, exposed to a period of increasing educational opportunities. These results are shown in Figures 2 and 3 for women and men respectively. Figures 2 and 3 show the results from within-family comparison models that i.) include only birth order as an explanatory variable, and ii.)

adjust for year of birth. More detailed information on the estimated coefficients can be found in the Supplementary Information in Table S1. Both Figures 2 and 3 show that in cohort groups where the mean level of educational attainment was relatively constant, the effect of birth order on educational attainment is negative even when not adjusting for birth year. However, amongst those born in the years 1965-1975, where educational attainment rose rapidly, later-borns spent substantially longer in the educational system than first-borns. This pattern can be seen clearly for both men and women.

*** Figure 2 – Approximately Here ***

*** Figure 3 – Approximately Here ***

Interestingly, these analyses also show that the negative effect of birth order is clear after adjusting for birth year, and correspondingly exposure to educational opportunities, and therefore the net effect of birth order on educational attainment is negative regardless of the period conditions in regards to educational expansion. It is worth noting that while the net effect of birth order on educational attainment is negative, there are large numbers of families in Sweden where later-born children were actually far more likely to go to university than their older siblings, and this is likely to be true across the many high-income countries that experienced educational expansion in the post-war period.

Analyses by Birth Interval Length and Gender

While the results presented in Figures 2 and 3 show that later-born individuals tend to

outperform their older siblings in periods where the supply of educational opportunities was increasing, the underlying assumption has been that the reason for this is because later-born children are born several years after the first-born child and thereby benefit from the increase in educational opportunities in the intervening period. That is to say, the degree of educational expansion in the intervening period is what provides the opportunity for later-born siblings to extend their educational careers to an extent far less possible for first-born individuals. To isolate the degree to which it is the period of time between the first and subsequent births that matters, I have conducted additional analyses where I restrict the models by the birth interval in sibling groups with only two children. The results shown in Figure 4 are bivariate associations between birth order and years of education by age 30, with separate results for women and men. Each data point shown on the graph is the difference between the second and first-born child for the particular birth interval period indicated by the x-axis. For example, second-born women in two-child sibling groups with a birth interval of 73-84 months have spent just under half a year longer in the educational system than first-borns by age 30.

*** Figure 4 – Approximately Here ***

For women in two-child sibling groups, there is no statistically significant difference in educational attainment by age 30 when the birth interval was between 0 and 12 months, while the second-born does significantly worse than the first-born when the interval was 13-24 months. However, in two-child sibling groups where the interval was 37 to 48 months or greater, the second child had spent more time in the educational system by age 30 than the first-born. The advantage is approximately 0.25 of a year when the

interval was 61-72 months, just over half a year when the interval was 73-84 months, and over a year when the interval was 109-120 months. For men the second child has lower educational attainment at age 30 than the first-born when the interval was less than 48 months, but when the interval was greater than 61 months the second-born begins to outperform the first-born. The advantage gained by second-born men, however, is less than that gained by second-born women. Even when the interval is 9 or 10 years a second-born man would have spent only approximately half a year longer in the educational system by age 30 than his older sibling.

The results for years of education by age 30 shown in Figure 4 clearly show that the birth interval, in combination with educational expansion, is the critical factor underlying the improvements in educational attainment shown by later-born siblings in periods of educational expansion. It is worth noting here that recent research has shown that birth spacing itself has no independent effect on long-term educational outcomes in Sweden amongst the cohorts studied in this paper (Barclay and Kolk, 2017), and therefore it is the expansion of educational opportunities that explains the pattern observed in Figure 4, not the benefits of avoiding resource dilution by having siblings spaced far apart.

Analyses by Sibling Group Size and Gender

Women

The results for educational attainment measured by years of education at age 30 can be seen for women in Figure 5, and for men in Figure 6. Figures 5 and 6 show the results for both pooled analyses as well as sibling group size-specific analyses for women and men

separately. Figures 5 and 6 show the results from within-family comparison models that i.) include only birth order as an explanatory variable, and ii.) adjust for year of birth. The tables of results underlying Figures 5 and 6 can be find in the supplementary section, in Tables S1-S3. Focusing on Figure 5, it can be seen that when adjusting for birth year, there is a negative relationship between birth order and educational attainment for women. This result is found in the pooled analysis of sibling groups with between two and six children, as well as the sibling group size-specific analyses. These results are statistically significant and substantive in size. In the pooled analysis, second-borns have almost a third of a year less education than first-borns, while the difference is greater than half a year less education for fourth-borns to sixth-borns.

While the net effect of birth order on educational attainment is negative for women, the results from the models that do not adjust for birth year show that later-born women actually have greater educational attainment than earlier born children when exposed to an increase in the supply of educational opportunities. This is true in both the pooled analysis of sibling groups with between 2 and 6 children, as well as the sibling group size-specific analyses. In the pooled analysis the second-born has almost a tenth of a year more education than first-borns, while sixth-borns have 1.23 years additional educational attainment. These results show that while the causal effect of birth order is negative, in the period under study, cohorts born between 1960 and 1982, later-born women have on average actually spent more time in the educational system by age 30 than earlier born women. Furthermore, the disparity between the causal estimates and the actual educational attainment of later-borns relative to first-borns is greatest for the last-borns in the largest sibling groups. This is because in small sibling groups the birth interval between the first and last child is on average substantially shorter than the birth

interval between the first and the last child in a six-child sibling group. Clearly, based on Figures 2 and 3, these results are primarily driven by the cohorts that benefitted from the increase in the supply of educational opportunities.

Analyses by Sibling Group Size and Gender

Men

The results for men by sibling group size can be seen in Figure 6. The results for the net effect of birth order, adjusting for birth year, on years of education are similar to those seen for women, both in the pooled analysis, as well as the sibling group size-specific analyses. The results from the pooled analysis show that second-borns have almost a third of a year less education than first-borns, while the difference between sixth-borns and first-borns is almost two thirds of a year. However, when examining the bivariate relationship between birth order and educational attainment, the advantage of later-borns over first-borns is less pronounced for men than it is for women. Amongst men, the second-born does not achieve greater educational attainment than the first-born in any size sibling group. The advantage gained for third- and later-borns is also less than that seen in the analyses of women. In the pooled analysis the sixth-born women spent more than a year in the educational system relative to the first-born, whereas for men the sixth-born spends just under two-thirds of a year more than the first-born. This is an advantage nonetheless, but a substantially smaller one. The explanation for this is due to the fact that increasing educational enrolment for women has outpaced increasing educational enrolment for men.

*** Figure 5 – Approximately Here ***

*** Figure 6 – Approximately Here ***

Robustness Checks

I have also conducted additional analyses using entrance into tertiary education by age 30 as the outcome variable. These results are consistent with the main results presented here, and can be seen in the supplementary information section, in Tables S4 and S5. Additional analyses have also been conducted to check whether the results presented here are robust when the study population consists of individuals whose parents did not have children with a third partner, meaning that there were no half-siblings, as half-siblings would introduce measurement error into the birth order variable. These results, available on request, do not differ from the main results presented here in any substantial way

DISCUSSION

This study has shown that while the net effect of birth order on educational attainment is negative, in an environment where educational opportunities have been expanding over time, this negative force is not only counterbalanced, but outweighed by these positive secular trends. Because the secular trend of rising educational attainment has been greater for women than for men, later-born girls during periods of educational expansion do better than their earlier born sisters, while later-born boys do not always do better than their older brothers during these periods. Because of the role of birth intervals, positive outcomes for later-born children are actually more common in sibling groups with a larger number of children during periods of educational expansion.

However, the results from this study also make it clear that in periods where education is not expanding, later-born siblings will do worse than their older siblings. When education is expanding, later-borns do better, but when it is not expanding, they do worse. As outlined in the introduction, it is very possible that educational expansion in the twentieth century is a factor contributing to the confusion about the effect that birth order has on the long-term prospects of individuals. For example, research using qualitative interviews to investigate the relationship between birth order and later life outcomes is likely to be picking up these positive period trends, which would explain why some researchers find that later-borns perform better.

The greater level of educational attainment that is achieved by later-born siblings born into periods where education was expanding is likely to have substantive implications. There are a large number of studies that show that higher levels of education have a positive effect on all manner of later life outcomes, from earnings to health (Hout, 2012). Research shows that social mobility is greater for individuals with tertiary education qualifications in Sweden (Breen, 2010) and the United States (Hout, 1988), amongst other places. Although a university degree has become the new entry standard for many types of jobs, and research in the United States shows that only a small proportion of students actually improve their critical thinking ability while at university (Arum and Roksa, 2011), studies indicate that university graduates still benefit from an earnings premium in Sweden (OECD, 2013). However, it should be noted that the rate of returns to education in Sweden has been declining (Palme and Wright, 1998; Korpi and Tåhlin, 2009), and that the positive effects of increasing education may be heterogeneous (Breen and Jonsson, 2007; Hällsten, 2010; Rudolphi, 2013). Despite these caveats, educational expansion across Western Europe, and over the course of the 20th century

575 to the present day (Erikson and Jonsson, 1996a; Breen et al., 2009; OECD, 2013), mean
576 that the findings presented in this study are likely to be generalizable both outside of
577 Sweden and outside of the cohorts that have been analysed in this study, though this
578 may vary according to university tuition regimes given the obstacles that high tuition
579 fees can present to pursuing educational opportunities.
580
581 Although this study has focused on the important of educational expansion for
582 increasing educational attainment amongst later-borns, there are also other factors that
583 could contribute to this advantage. For example, it is well known that first-borns have a
584 lower birth weight than later-borns, and birth weight is positively associated with a
585 range of later life outcomes, including educational attainment, IQ, and earnings (Conley
586 and Bennett, 2000; Hack et al., 2002; Black et al., 2007). Parental resources also typically
587 increase with parental age, which has the potential to benefit later-born siblings (Powell
588 et al., 2006). There have also been other improvements over the past several decades in
589 Sweden that would have, on average, benefitted later-borns over earlier born siblings,
590 such as the expansion of the welfare state, strong economic growth (Erikson and
591 Jonsson, 1996b), the introduction of publicly funded pre-school in the 1970s (Halldén,
592 2008), and general improvements to public health conditions and to medical practice,
593 which have measurably improved health over time (Statistics Sweden, 2010). However,
594 as the analyses shown in Figures 4 and 5 in this study demonstrate, later-born siblings
595 only achieve greater educational attainment when education is expanding, suggesting
596 that these other factors play a fairly limited role.
597
598 A recent study examining the relationship between birth order and earnings has also
599 shown that later-borns are not always disadvantaged when it comes to long-term

outcomes (Bertoni and Brunello, 2016). Bertoni and Brunello (2016) report that although first-borns have a higher entry wage in the labour market, on average this advantage reverses to later-borns after 10 years due to a greater willingness amongst later-borns to be more adaptable and switch jobs. This difference in willingness to switch jobs, they argue, is due to differences in risk aversion by birth order, with first-borns more risk averse than later-borns. Although Bertoni and Brunello (2016) purport an entirely different mechanism to the one that I describe in this study, together these results show that it is far from a given that later-born siblings will always have worse outcomes than first-borns.

This study has shown that later-born siblings can achieve greater educational attainment than older siblings when education is expanding. Other research has also shown that positive secular trends in IQ scores mean that individuals born to older mothers have higher IQ scores (Myrskylä, Silventoinen, Tynelius and Rasmussen 2013), and that when population height is increasing, later-born siblings are taller than first-borns (Alter and Oris, 2008). Given the Flynn effect (Flynn 1984), and increases in height in Sweden in the 20th century (Gustafsson et al., 2007), it is possible that the counterbalancing influence of positive secular trends outweighs the negative force of birth order on both height (Myrskylä, Silventoinen, Jelenkovic, Tynelius and Rasmussen 2013) and cognitive ability (Barclay, 2015b). Overall, what this body of research suggests is that while the force of birth order on a range of later life outcomes is negative, positive secular trends have meant that later-borns often do better than their earlier-born siblings. Although identifying the causal effect of birth order is an important exercise, isolating the effect of birth order net of birth year ignores the fact that the context into which individuals are born changes over time. Given the consistent and

widespread interest in the importance of birth order for later life outcomes, it would be valuable for researchers to bear this in mind as part of a broader consideration of the implications of birth order, rather than focusing exclusively on the negative net effect.

REFERENCES

Alter, G. and Oris, M. (2008). Effects of inheritance and environment on the heights of brothers in nineteenth-century Belgium. *Human Nature,* **19**(1), 44–55.

Arum, R. and Roksa, J. (2011). *Academically Adrift: Limited Learning on College Campuses*. Chicago: University of Chicago Press.

Barclay, K. J. (2015a). Birth order and educational attainment: evidence from fully adopted sibling groups. *Intelligence*, **48**, 109-122.

Barclay, K. J. (2015b). A Within-family analysis of birth order and intelligence using population conscription data on Swedish men. *Intelligence*, **49**, 134-143.

Barclay, K. J. and Kolk, M. (2017). The long-term cognitive and socioeconomic consequences of birth intervals: A within-family sibling comparison using Swedish register data. *Demography*, **54**(2), 459-484.

Bertoni, M., & Brunello, G. (2016). Laterborns don't give up: the temporary effects of birth order on European earnings. *Demography,* **53**(2), 449-470.

Black, S. E., Devereux, P. J. and Salvanes, K. G. (2005). The more the merrier? The effect of family size and birth order on children's education. *Quarterly Journal of Economics*, **120**(2), 669–700.

Black, S. E., Devereux, P. J. and Salvanes, K. G. (2007). From the cradle to the labor market? The effect of birth weight on adult outcomes. *Quarterly Journal of Economics*, **122**(1), 409–439.

Blake, J. (1981). Family size and the quality of children. *Demography*, **18**, 421–442.

Blake, J. (1989a). Number of siblings and educational attainment. *Science*, **245**(4913), 32–36.

Blake, J. (1989b). *Family Size & Achievement, Vol. 3*. Berkeley: University of California Press.

Blau, P. M. and Duncan, O. D. (1967). *The American Occupational Structure*. New York: John Wiley & Sons.

Breen, R. (2010). Educational expansion and social mobility in the 20th century. *Social Forces*, **89**(2), 365–388.

Breen, R. and Jonsson, J. O. (2007). Explaining change in social fluidity: educational equalization and educational expansion in twentieth-century Sweden. *American Journal of Sociology*, **112**(6), 1775–1810.

Breen, R., Luijkx, R., Müller, W. and Pollak, R. (2009). Nonpersistent inequality in educational attainment: evidence from eight European countries. *American Journal of*

718 *Sociology*, 114(5), 1475–1521.
719
720 Breen, R., Luijkx, R., Müller, W. and Pollak, R. (2010). Long-term trends in educational
721 inequality in Europe: class inequalities and gender differences. *European Sociological*
722 *Review*, **26**(1), 31-48.
723
724 Buchmann, C., DiPrete, T. A., and McDaniel, A. (2008). Gender inequalities in
725 education. *Annual Review of Sociology*, **34**, 319-337.
726
727 Buckles, K. and Kolka, S. (2014). Prenatal investments, breastfeeding, and birth order.
728 *Social Science & Medicine*, **118**, 66-70.
729
730 Conley, D. (2004). *The Pecking Order: Which Siblings Succeed and Why*. New York:
731 Pantheon.
732
733 Conley, D. and Bennett, N. G. (2000). Is biology destiny? Birth weight and life chances.
734 *American Sociological Review*, **65**(3), 458–467.
735
736 Cunha, F., Heckman, J. J., Lochner, L., and Masterov, D. V. (2006). Interpreting the
737 evidence on life cycle skill formation. *Handbook of the Economics of Education*, **1**, 697-
738 812.
739
740 Erikson, R. and Jonsson, J. O. (1996a), The Swedish context: educational reform and
741 long-term change in educational inequality. In Erikson, R. and Jonsson, J. O. (Eds.), *Can*
742 *Education Be Equalized? The Swedish Case in Comparative Perspective*. Boulder, CO:
743 Westview Press.
744
745 Erikson, R. and Jonsson, J. O. (1996b). *Can Education be Equalized? The Swedish Case in*
746 *Comparative Perspective*. Boulder, CO: Westview Press.
747
748 Ernst, C. and Angst, J. (1983). *Birth Order: Its Influence on Personality*. Berlin: Springer-
749 Verlag.
750
751 Flynn, J. R. (1987). Massive IQ gains in 14 nations: what IQ tests really
752 measure. *Psychological Bulletin,* **101**(2), 171-191.
753
754 Galton, F. (1874). *English Men of Science: Their Nature and Nurture*. London: MacMillan &
755 Company.
756
757 Gelb, J. (1989). *Feminism and Politics: A Comparative Perspective*. Berkeley, CA:
758 University of California Press.
759
760 Gini, C. (1915). Superiority of the eldest investigation among professors in italian
761 universities shows that the first-born are most frequent among them, while children
762 born late in the generation are the rarest. *Journal of Heredity*, **6**(1), 37–39.
763
764 Gustafsson, A., Werdelin, L., Tullberg, B. S. and Lindenfors, P. (2007). Stature and sexual
765 stature dimorphism in Sweden, from the 10th to the end of the 20th century. *American*
766 *Journal of Human Biology,* **19**(6): 861-870.

Goldin, C., and Katz, L. F. (2002). The power of the pill: oral contraceptives and women's career and marriage decisions. *Journal of Political Economy,* **110**(4), 730–770.

Hack, M., Flannery, D. J., Schluchter, M., Cartar, L., Borawski, E. and Klein, N. (2002). Outcomes in young adulthood for very-low-birth-weight infants. *New England Journal of Medicine*, **346**(3), 149–157.

Halldén, K. (2008). The Swedish educational system and classifying education using the ISCED- 97. In Schneider, S. (Ed.), *The International Standard Classification of Education (ISCED-97). An Evaluation of Content and Criterion Validity in 15 European Countries*. MZES, Mannheim, pp. 253–267.

Hällsten, M. (2010). The structure of educational decision making and consequences for inequality: a Swedish test case. *American Journal of Sociology*, **116**(3), 806-54.

Härkönen, J. (2014). Birth order effects on educational attainment and educational transitions in West Germany. *European Sociological Review*, **30**(2), 166–179.

Heckman, J. J. (2006). Skill formation and the economics of investing in disadvantaged children. *Science*, **312**(5782), 1900-1902.

Heckman, J. J. (2007). The economics, technology, and neuroscience of human capability formation. *Proceedings of the National Academy of Sciences*, **104**(33), 13250-13255.

Hertwig, R., Davis, J. N., and Sulloway, F. J. (2002). Parental investment: how an equity motive can produce inequality. *Psychological Bulletin*, **128**(5), 728-745.

Högskoleverket (2012). *Swedish Universities and University Colleges: Short Version of Annual Report 2012*. Stockholm: Högskoleverket.

Hout, M. (1988). More universalism, less structural mobility: the American occupational structure in the 1980s. *American Journal of Sociology,* **93**(6), 1358-1400.

Hout, M. (2012). Social and economic returns to college education in the United States. *Annual Review of Sociology*, **38**, 379-400.

Jackson, M. (2013). *Determined to Succeed? Performance Versus Choice in Educational Attainment*. Stanford: Stanford University Press.

Kalmijn, M. and Kraaykamp, G. (2005). Late or later? A sibling analysis of the effect of maternal age on children's schooling. *Social Science Research*, **34**, 634–650.

Kantarevic, J. and Mechoulan, S. (2006). Birth order, educational attainment, and earnings an investigation using the PSID. *Journal of Human Resources*, **41**(4), 755–777.

Korpi, T. and Tåhlin, M. (2009). Educational mismatch, wages, and wage growth: overeducation in Sweden, 1974–2000*. Labour Economics*, **16**(2), 183–193.

816 Kristensen, P. and Bjerkedal, T. (2007). Explaining the relation between birth order and
817 intelligence. *Science*, **316**(5832), 1717.
818
819 Kristensen, P. and Bjerkedal, T. (2010). Educational attainment of 25 year old
820 Norwegians according to birth order and gender. *Intelligence*, **38**(1), 123–136.
821
822 Lager, A. C. J. and Torssander, J. (2012). Causal effect of education on mortality in a
823 quasi-experiment on 1.2 million Swedes. *Proceedings of the National Academy of*
824 *Sciences*, **109**(22), 8461–8466.
825
826 Myrskylä, M., Silventoinen, K., Tynelius, P. and Rasmussen, F. (2013). Is later better or
827 worse? Association of advanced parental age with offspring cognitive ability among half
828 a million young Swedish men. *American Journal of Epidemiology*, **177**(7), 649–655.
829
830 Myrskylä, M., Silventoinen, K., Jelenkovic, A., Tynelius, P., & Rasmussen, F. (2013). The
831 association between height and birth order: evidence from 652 518 Swedish
832 men. *Journal of Epidemiology and Community Health*, **67**, 571-577.
833
834 OECD (2013). *Education at a Glance 2013: OECD Indicators*. OECD Publishing.
835 http://dx.doi.org/10.1787/eag-2013-en.
836
837 Palme, M. O. and Wright, R. E. (1998). Changes in the rate of return to education in
838 Sweden: 1968-1991. *Applied Economics*, **30**(12), 1653–1663.
839
840 Powell, B., Steelman, L. C., & Carini, R. M. (2006). Advancing age, advantaged youth:
841 parental age and the transmission of resources to children. *Social Forces*, **84**(3), 1359-
842 1390.
843
844 Price, J. (2008). Parent-Child Quality Time Does Birth Order Matter?. *Journal of Human*
845 *Resources*, **43**(1), 240-265.
846
847 Reynolds, A. J., Temple, J. A., & Ou, S. R. (2003). School-based early intervention and child
848 well-being in the Chicago Longitudinal Study. *Child Welfare*, **82**(5), 633-656.
849
850 Rodgers, J. L. (2001). What causes birth order-intelligence patterns? the admixture
851 hypothesis, revived. *American Psychologist*, **56**, 505–510.
852
853 Rudolphi, F. (2013). Ever declining inequalities? Transitions to upper secondary and
854 tertiary education in Sweden, 1972-1990 birth cohorts. In Jackson, M. (Ed.), *Determined*
855 *to Succeed? Performance Versus Choice in Educational Attainment*. Stanford: Stanford
856 University Press, chapter 7.
857
858 Schooler, C. (1972). Birth order effects: Not here, not now! *Psychological Bulletin*, **78**(3),
859 161–175.
860
861 Sénéchal, M., Lefevre, J. A., Thomas, E. M., & Daley, K. E. (1998). Differential effects of
862 home literacy experiences on the development of oral and written language. *Reading*
863 *Research Quarterly*, 33(1), 96-116.
864

865 Sénéchal, M., & LeFevre, J. A. (2002). Parental involvement in the development of
866 children's reading skill: A five-year longitudinal study. *Child Development*, 73(2), 445-
867 460.
868
869 Stanovich, K. E. (1986). Matthew effects in reading: Some consequences of individual
870 differences in the acquisition of literacy. *Reading Research Quarterly*, 21(4), 360-407.
871
872 Statistics Sweden (2000). *Svensk utbildningsnomenklatur, SUN2000*. Stockholm:
873 Statistics Sweden.
874
875 Steelman, L. C., Powell, B., Werum, R., and Carter, S. (2002). Reconsidering the effects of
876 sibling configuration: Recent advances and challenges. *Annual Review of Sociology*, **28**,
877 243-269.
878
879 Sulloway, F. J. (1996). *Born to Rebel: Birth Order, Family Dynamics, and Creative Lives.*
880 London: Little, Brown and Company.
881
882 Sundström, M., & Duvander, A. Z. E. (2002). Gender division of childcare and the sharing
883 of parental leave among new parents in Sweden. *European Sociological Review*, **18**(4),
884 433-447.
885
886 Taylor, P., Parker, K., Morin, R., Fry, R., Patten, E. and Brown, A. (2014). *The Rising Costs*
887 *of Not Going to College*. Washington, DC: Pew Research Center Social & Demographic
888 Trends project, February.
889
890 Thomson, E. (2014). Family complexity in Europe. *The ANNALS of the American Academy*
891 *of Political and Social Science*, 654(1), 245–258.
892
893 Toman, W. (1961). *Family Constellation: Its Effects on Personality and Social Behavior*.
894 New York: Springer.
895
896 Weisleder, A., and Fernald, A. (2013). Talking to children matters: early language
897 experience strengthens processing and builds vocabulary. *Psychological Science*, 24(11),
898 2143-2152.
899
900 Willemse, N. and De Beer, P. (2012). Three worlds of educational welfare states? A
901 comparative study of higher education systems across welfare states. *Journal of*
902 *European Social Policy*, 22(2), 105–117.
903
904 Zajonc, R. B. (1976). Family configuration and intelligence. *Science*, **192**, 227–236.

905 Zajonc, R. B., Markus, H. and Markus, G. B. (1979). The birth order puzzle. *Journal of*
906 *Personality and Social Psychology* **37**(8), 1325-1341.
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910 **TABLES**

911

912 **Table 1. Sample exclusion process.**

913

Exclusion Criteria	N	N Excluded
Total Born in Sweden 1960-1982	2,435,773	
ID for both parents	2,405,610	30,163
All siblings born in Sweden	2,364,749	40,861
No multiple births	2,304,319	60,430
No only children	1,928,247	376,072
Biological set size<7	1,913,165	15,082
Cohort cut	1,663,128	250,549
No missing values on any variables	1,578,667	84,461
Final	1,578,667	

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929 **Table 2. Descriptive Statistics: Years of Educational Attainment at Age 30 for**
930 **Swedish Men and Women born 1960-1982.**
931

		Women			Men		
Variable	Category	Mean	SD	N	Mean	SD	N
Years of Education		12.9	2.3	766,226	12.5	2.3	812,441
Birth Order	1	12.9	2.3	308,929	12.5	2.3	328,149
	2	12.9	2.3	324,725	12.5	2.2	344,676
	3	12.7	2.3	100,582	12.3	2.2	106,215
	4	12.3	2.3	23,892	11.8	2.2	25,056
	5	11.8	2.1	6,419	11.5	2.0	6,610
	6	11.7	2.0	1,679	11.3	1.9	1,735
Set Size	2	13.0	2.3	416,020	12.6	2.2	438,981
	3	12.9	2.3	246,349	12.5	2.3	263,707
	4	12.5	2.3	74,437	12.1	2.2	79,249
	5	12.1	2.2	21,277	11.7	2.1	22,343
	6	11.8	2.1	8,143	11.4	2.1	8,161
Mother's Age at	<20	11.7	1.9	42,431	11.4	1.8	44,308
Time of Birth	20-24	12.4	2.2	236,722	12.0	2.1	250,655
	25-29	13.1	2.3	288,274	12.7	2.3	306,663
	30-34	13.4	2.3	147,516	12.9	2.3	156,128
	35-39	13.2	2.3	43,854	12.8	2.3	47,033
	40-44	12.9	2.3	7,129	12.5	2.3	7,317
	>44	12.9	2.3	300	12.1	2.3	337
Birth Year	1960	11.9	2.1	22,613	11.8	2.2	23,797
	1961	12.0	2.1	24,185	11.8	2.2	25,688
	1962	12.0	2.0	27,331	11.8	2.2	28,802
	1963	12.0	2.1	31,548	11.9	2.2	33,738
	1964	12.1	2.0	37,431	11.9	2.1	39,051
	1965	12.1	2.0	39,694	11.9	2.1	42,032
	1966	12.2	2.0	40,909	12.0	2.1	43,481
	1967	12.2	2.0	41,376	12.0	2.1	44,374
	1968	12.3	2.1	39,468	12.1	2.1	41,703
	1969	12.4	2.1	37,971	12.1	2.1	40,635
	1970	12.7	2.2	38,755	12.3	2.2	40,892
	1971	12.9	2.2	39,957	12.4	2.2	42,502
	1972	13.1	2.3	39,575	12.6	2.3	42,009
	1973	13.3	2.3	38,706	12.7	2.3	41,087
	1974	13.4	2.3	38,738	12.9	2.3	41,145
	1975	13.6	2.2	36,068	13.1	2.2	38,043
	1976	13.8	2.2	33,550	13.2	2.2	35,718
	1977	13.8	2.2	31,911	13.1	2.2	34,448
	1978	13.8	2.3	30,448	13.0	2.4	31,896
	1979	13.8	2.3	29,000	13.0	2.4	30,777
	1980	13.9	2.2	25,533	13.1	2.2	26,962
	1981	13.8	2.2	21,396	13.1	2.2	22,271
	1982	13.8	2.2	20,063	13.0	2.2	21,390

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934 **FIGURES**
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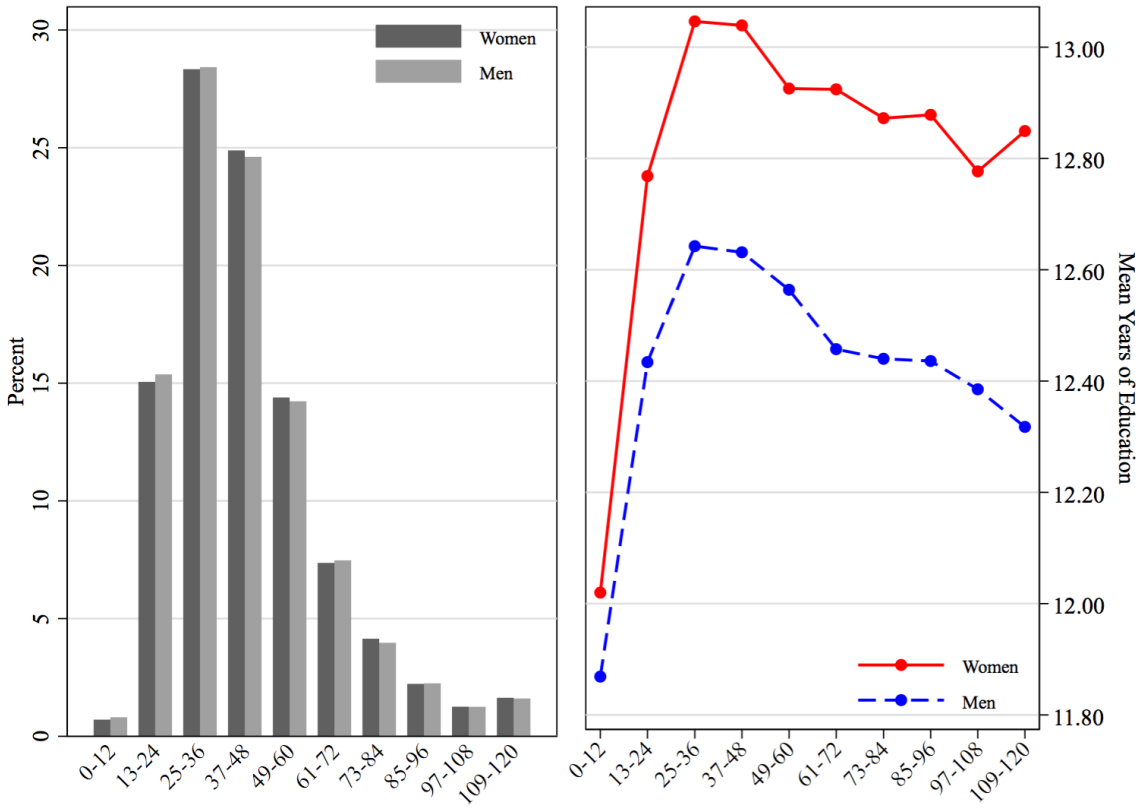

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937 **Figure 1. Distribution of Birth Intervals and Mean Years of Education by Age 30 by**
938 **Birth Interval Length in Months, for Swedish Women and Men Born 1960-1982 in**
939 **Two-child Sibling Groups.**
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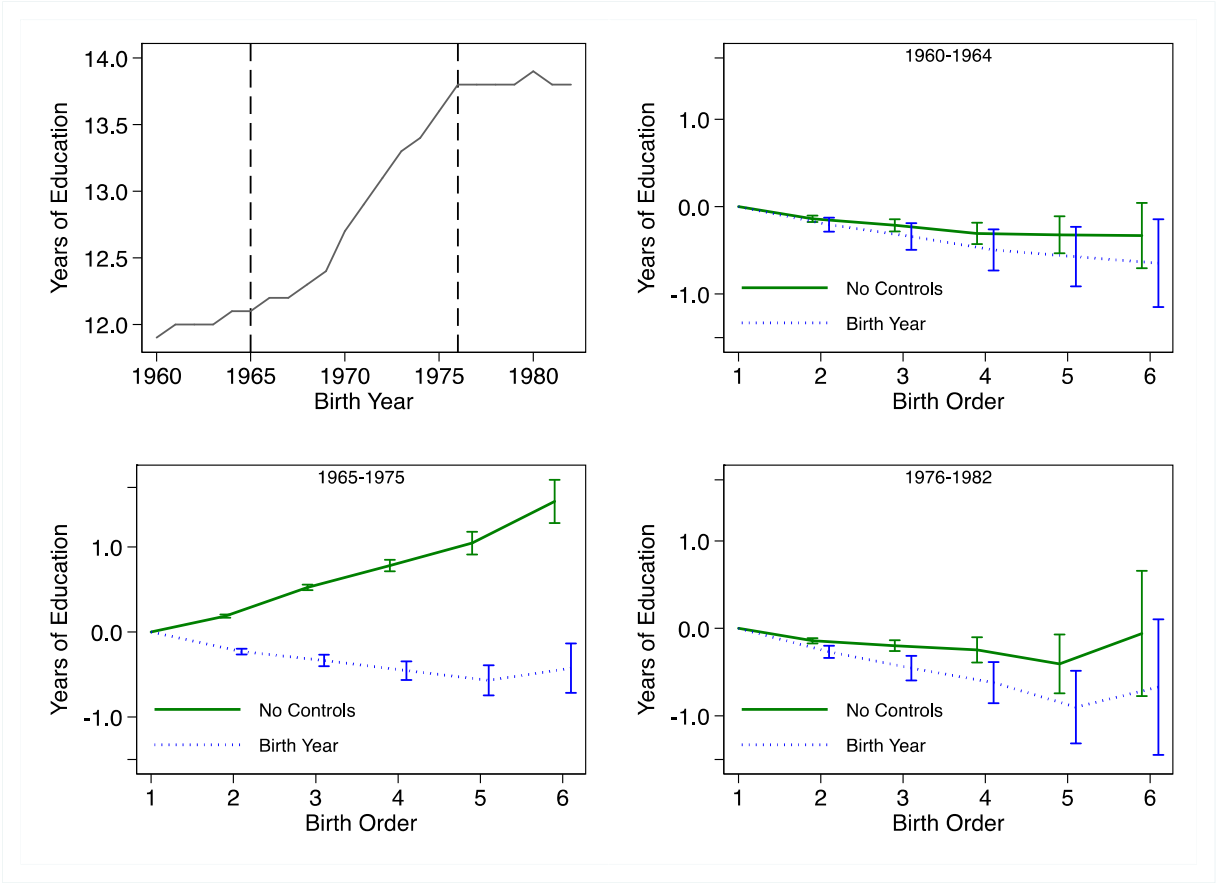


Figure 2. Swedish Women Born 1960-1982: Birth Order and Years of Education at Age 30 by Cohort Groups 1960-1964, 1965-1975, and 1976-1982.

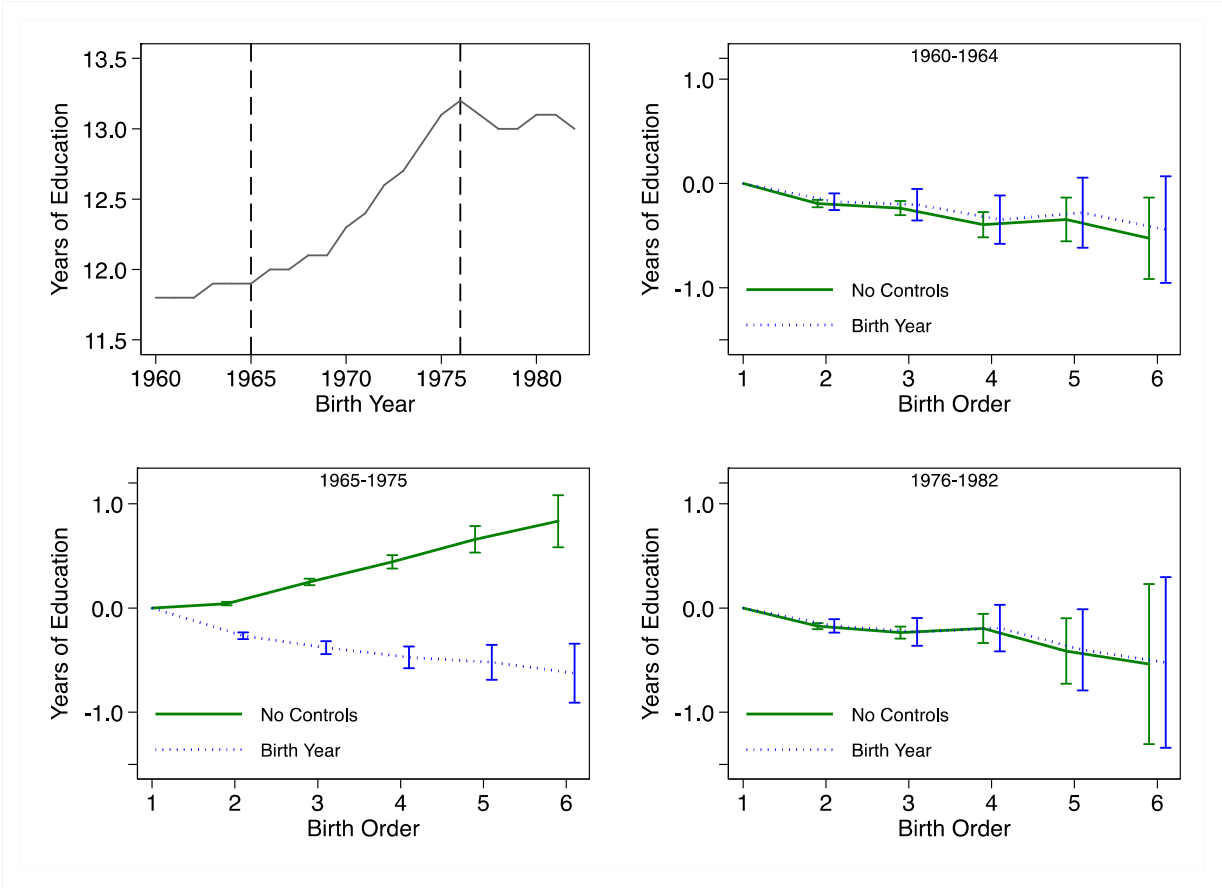
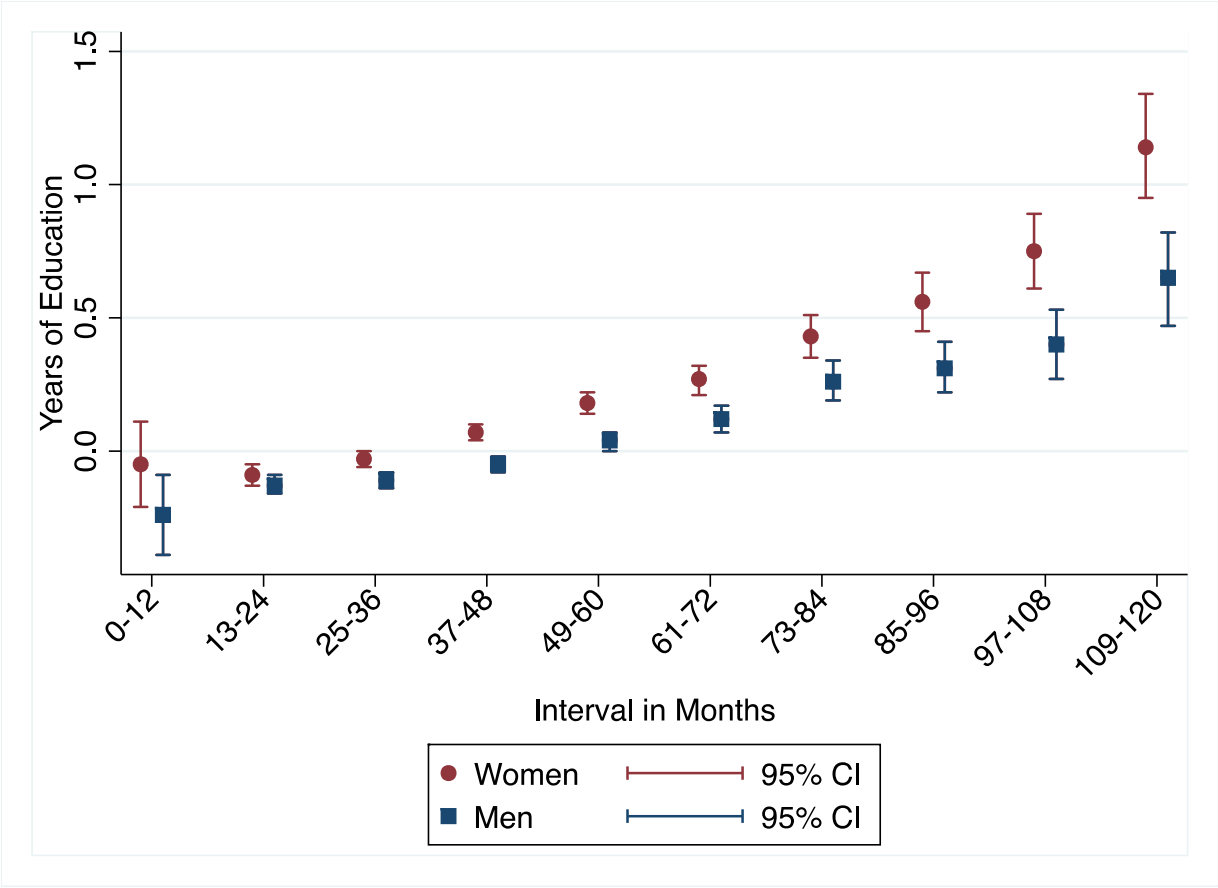


Figure 3. Swedish Men Born 1960-1982: Birth Order and Years of Education at Age 30 by Cohort Groups 1960-1964, 1965-1975, and 1976-1982.



961
962 **Figure 4. Swedish Men and Women Born 1960-1982: Years of Education at Age 30**
963 **by Birth Intervals in Two-child Sibling Groups.**
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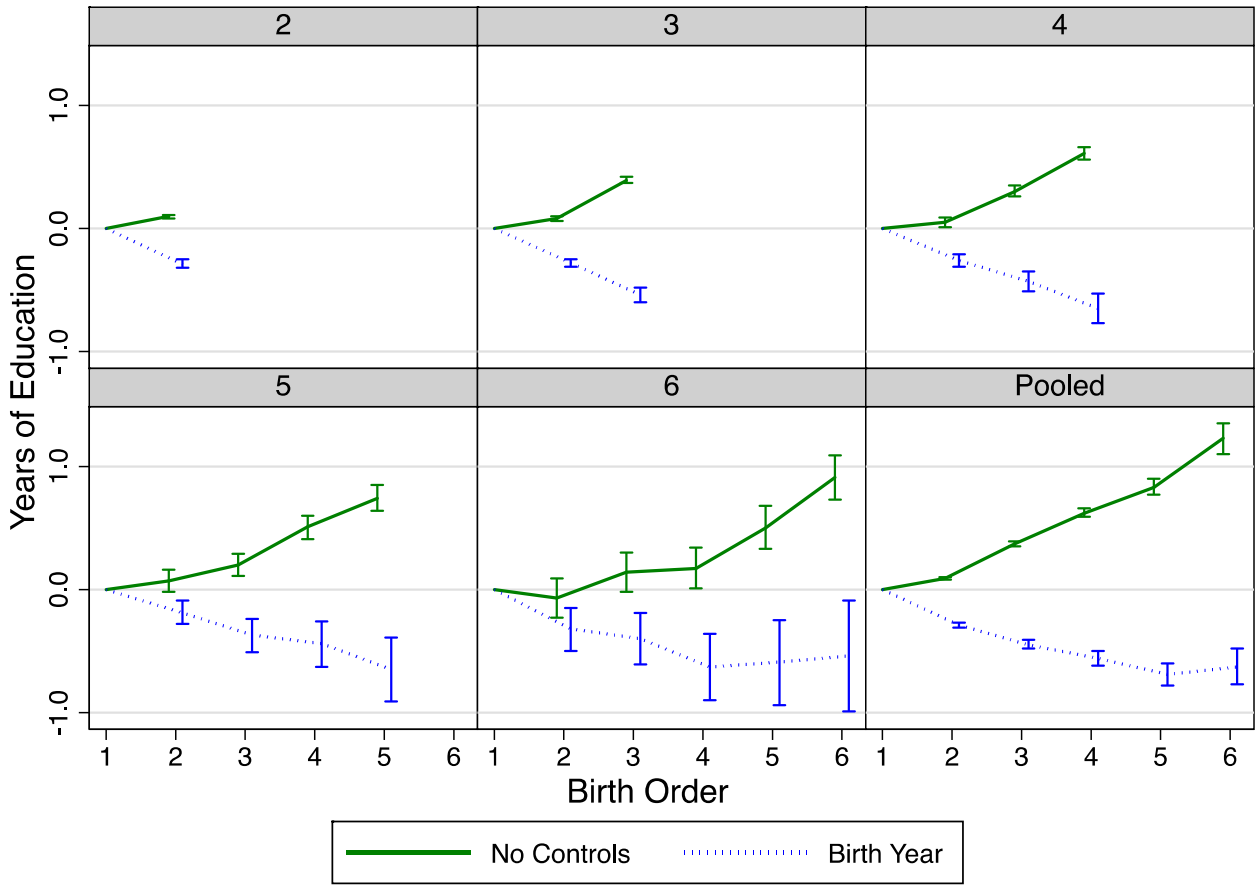

Figure 5. Swedish Women Born 1960-1982: Years of Education at Age 30 by Sibling Group Size.

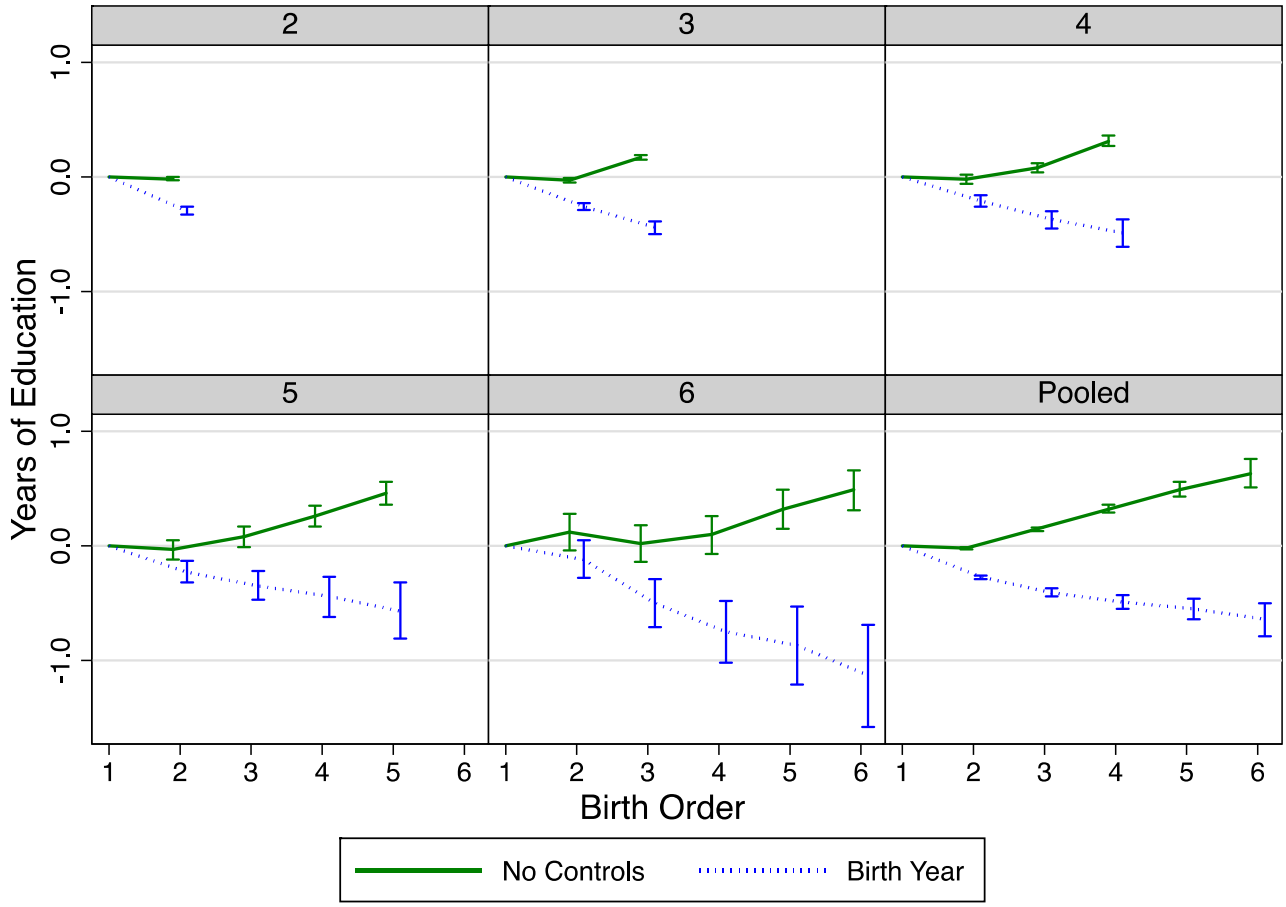

Figure 6. Swedish Men Born 1960-1982: Years of Education at Age 30 by Sibling Group Size.

Supplementary Information

Table S1. Women and men born 1960-1982: within-family comparison results from analyses of the relationship between birth order and years of education at age 30 using fixed effects linear regressions by cohort groups 1960-1964, 1965-1975, and 1976-1982.

		Women				Men			
		Bivariate		Adjusting for Birth Year		Bivariate		Adjusting for Birth Year	
Birth Cohort	Birth Order	Beta	95% CI	Beta	95% CI	Beta	95% CI	Beta	95% CI
1960-1964	1 (ref)	0.00		0.00		0.00		0.00	
	2	-0.21	-0.29, -0.13	-0.14	-0.18, -0.10	-0.18	-0.25, -0.10	-0.19	-0.23, -0.16
	3	-0.34	-0.49, -0.19	-0.21	-0.28, -0.14	-0.20	-0.35, -0.05	-0.24	-0.30, -0.17
	4	-0.50	-0.73, -0.26	-0.31	-0.43, -0.18	-0.35	-0.58, -0.11	-0.39	-0.52, -0.27
	5	-0.57	-0.91, -0.23	-0.32	-0.53, -0.11	-0.28	-0.62, 0.06	-0.34	-0.56, -0.13
	6	-0.65	-1.15, -0.15	-0.33	-0.71, 0.04	-0.44	-0.95, 0.07	-0.53	-0.92, -0.13
1965-1975	1 (ref)	0.00		0.00		0.00		0.00	
	2	-0.23	-0.27, -0.20	0.19	0.17, 0.20	-0.27	-0.30, -0.23	0.04	0.02, 0.06
	3	-0.34	-0.40, -0.27	0.52	0.49, 0.56	-0.38	-0.44, -0.32	0.25	0.22, 0.28
	4	-0.45	-0.56, -0.34	0.78	0.71, 0.85	-0.47	-0.58, -0.37	0.44	0.38, 0.51
	5	-0.57	-0.75, -0.39	1.04	0.91, 1.18	-0.52	-0.69, -0.35	0.66	0.53, 0.79
	6	-0.43	-0.72, -0.14	1.53	1.28, 1.79	-0.62	-0.91, -0.34	0.83	0.58, 1.08
1976-1982	1 (ref)	0.00		0.00		0.00		0.00	
	2	-0.27	-0.34, -0.20	-0.14	-0.17, -0.11	-0.17	-0.24, -0.11	-0.17	-0.20, -0.14
	3	-0.46	-0.60, -0.32	-0.20	-0.26, -0.14	-0.23	-0.36, -0.10	-0.24	-0.29, -0.18
	4	-0.62	-0.86, -0.39	-0.25	-0.39, -0.10	-0.19	-0.42, 0.03	-0.20	-0.34, -0.06
	5	-0.90	-1.32, -0.49	-0.41	-0.74, -0.07	-0.40	-0.79, -0.01	-0.41	-0.73, -0.10
	6	-0.67	-1.45, 0.10	-0.06	-0.78, 0.66	-0.52	-1.34, 0.30	-0.54	-1.30, 0.23

Table S2. Women born 1960-1982: within-family comparison results from analyses of the relationship between birth order and years of education at age 30 using fixed effect linear regressions.

		Bivariate			Adjusting for Birth Year		
Variable	Category	Beta	SE	95% CI	Beta	SE	95% CI
Birth Order	1	0.00			0.00		
	2	0.09	0.01	0.08, 0.10	-0.29	0.01	-0.31, -0.27
	3	0.37	0.01	0.35, 0.39	-0.45	0.02	-0.48, -0.41
	4	0.62	0.02	0.59, 0.66	-0.56	0.03	-0.62, -0.50
	5	0.83	0.03	0.77, 0.90	-0.69	0.05	-0.78, -0.60
	6	1.23	0.07	1.10, 1.35	-0.63	0.08	-0.77, -0.48
Cohort	1960				-0.84	0.03	-0.90, -0.77
	1961				-0.78	0.03	-0.84, -0.72
	1962				-0.73	0.03	-0.79, -0.67
	1963				-0.66	0.03	-0.71, -0.61
	1964				-0.62	0.03	-0.67, -0.57
	1965				-0.57	0.02	-0.61, -0.52
	1966				-0.49	0.02	-0.53, -0.45
	1967				-0.43	0.02	-0.47, -0.39
	1968				-0.39	0.02	-0.43, -0.35
	1969				-0.30	0.02	-0.34, -0.26
	1970				0.00		
	1971				0.19	0.02	0.15, 0.23
	1972				0.39	0.02	0.35, 0.43
	1973				0.55	0.02	0.51, 0.59
	1974				0.77	0.02	0.72, 0.81
	1975				0.97	0.02	0.93, 1.02
	1976				1.09	0.03	1.04, 1.14
	1977				1.19	0.03	1.14, 1.24
	1978				1.14	0.03	1.09, 1.20
	1979				1.24	0.03	1.18, 1.30
	1980				1.34	0.03	1.28, 1.41
	1981				1.35	0.04	1.28, 1.42
	1982				1.38	0.04	1.31, 1.46
N			766,226			766,226	

Table S3. Men born 1960-1982: within-family comparison results from analyses of the relationship between birth order and years of education at age 30 using fixed effect linear regressions.

		Bivariate			Adjusting for Birth Year		
Variable	Category	Beta	SE	95% CI	Beta	SE	95% CI
Birth Order	1	0.00			0.00		
	2	-0.02	0.01	-0.03, -0.01	-0.27	0.01	-0.29, -0.26
	3	0.15	0.01	0.13, 0.16	-0.41	0.02	-0.44, -0.37
	4	0.32	0.02	0.29, 0.36	-0.49	0.03	-0.55, -0.43
	5	0.49	0.03	0.43, 0.56	-0.55	0.04	-0.64, -0.46
	6	0.63	0.06	0.51, 0.76	-0.64	0.07	-0.79, -0.50
Cohort	1960				-0.55	0.03	-0.62, -0.49
	1961				-0.55	0.03	-0.61, -0.49
	1962				-0.53	0.03	-0.59, -0.48
	1963				-0.48	0.03	-0.53, -0.43
	1964				-0.44	0.02	-0.49, -0.40
	1965				-0.40	0.02	-0.45, -0.36
	1966				-0.33	0.02	-0.37, -0.29
	1967				-0.31	0.02	-0.35, -0.27
	1968				-0.29	0.02	-0.32, -0.25
	1969				-0.22	0.02	-0.26, -0.18
	1970				0.00		
	1971				0.08	0.02	0.04, 0.12
	1972				0.22	0.02	0.18, 0.26
	1973				0.37	0.02	0.33, 0.41
	1974				0.52	0.02	0.47, 0.56
	1975				0.72	0.02	0.67, 0.76
	1976				0.82	0.02	0.78, 0.87
	1977				0.80	0.03	0.75, 0.85
	1978				0.73	0.03	0.67, 0.78
	1979				0.77	0.03	0.72, 0.83
	1980				0.93	0.03	0.87, 0.99
	1981				0.90	0.03	0.83, 0.96
	1982				0.93	0.04	0.86, 1.00
N			812,441			812,441	

Table S4. Women and men born 1960-1982: within-family comparison results from analyses of the relationship between birth order and years of education at age 30 using fixed effects linear regressions by the size of the sibling group of origin.

		Women				Men			
		Bivariate		Adjusting for Birth Year		Bivariate		Adjusting for Birth Year	
Set Size	Birth Order	Beta	95% CI	Beta	95% CI	Beta	95% CI	Beta	95% CI
Pooled	1 (ref)	0.00		0.00		0.00		0.00	
	2	0.09	0.08, 0.10	-0.29	-0.31, -0.27	-0.02	-0.03, -0.01	-0.27	-0.29, -0.26
	3	0.37	0.35, 0.39	-0.45	-0.48, -0.41	0.15	0.13, 0.16	-0.41	-0.44, -0.37
	4	0.62	0.59, 0.66	-0.56	-0.62, -0.50	0.32	0.29, 0.36	-0.49	-0.55, -0.43
	5	0.83	0.77, 0.90	-0.69	-0.78, -0.60	0.49	0.43, 0.56	-0.55	-0.64, -0.46
	6	1.23	1.10, 1.35	-0.63	-0.77, -0.48	0.63	0.51, 0.76	-0.64	-0.79, -0.50
2	1 (ref)	0.00		0.00		0.00		0.00	
	2	0.10	0.08, 0.11	-0.29	-0.32, -0.25	-0.02	-0.03, 0.00	-0.30	-0.33, -0.26
3	1 (ref)	0.00		0.00		0.00		0.00	
	2	0.08	0.06, 0.10	-0.28	-0.31, -0.25	-0.03	-0.05, -0.01	-0.26	-0.29, -0.23
	3	0.39	0.37, 0.42	-0.54	-0.60, -0.48	0.17	0.15, 0.19	-0.44	-0.50, -0.39
4	1 (ref)	0.00		0.00		0.00		0.00	
	2	0.05	0.01, 0.09	-0.26	-0.31, -0.21	-0.02	-0.06, 0.02	-0.21	-0.26, -0.16
	3	0.30	0.26, 0.35	-0.43	-0.51, -0.35	0.08	0.04, 0.12	-0.37	-0.45, -0.30
	4	0.61	0.56, 0.66	-0.65	-0.77, -0.53	0.31	0.27, 0.36	-0.49	-0.61, -0.37
5	1 (ref)	0.00		0.00		0.00		0.00	
	2	0.07	-0.02, 0.16	-0.19	-0.28, -0.09	-0.03	-0.12, 0.05	-0.23	-0.32, -0.13
	3	0.20	0.11, 0.29	-0.37	-0.51, -0.24	0.08	-0.01, 0.17	-0.35	-0.47, -0.22
	4	0.51	0.41, 0.60	-0.44	-0.63, -0.26	0.26	0.17, 0.35	-0.44	-0.62, -0.27
	5	0.74	0.64, 0.85	-0.65	-0.91, -0.39	0.46	0.36, 0.56	-0.57	-0.81, -0.32
6	1 (ref)	0.00		0.00		0.00		0.00	
	2	-0.07	-0.23, 0.09	-0.32	-0.50, -0.15	0.12	-0.04, 0.28	-0.12	-0.28, 0.05
	3	0.14	-0.02, 0.30	-0.40	-0.61, -0.19	0.02	-0.14, 0.18	-0.50	-0.71, -0.29
	4	0.17	0.01, 0.34	-0.63	-0.90, -0.36	0.10	-0.07, 0.26	-0.75	-1.02, -0.48
	5	0.50	0.33, 0.68	-0.59	-0.94, -0.25	0.32	0.15, 0.49	-0.87	-1.21, -0.53
	6	0.91	0.73, 1.09	-0.54	-0.99, -0.09	0.49	0.31, 0.66	-1.13	-1.58, -0.69

Table S5. Women born 1960-1982: within-family comparison results from analyses of the relationship between birth order and entering tertiary education by age 30 using fixed effect logistic regressions.

		Bivariate			Adjusting for Birth Year		
Variable	Category	OR	SE	95% CI	OR	SE	95% CI
Birth Order	1	1.00			1.00		
	2	1.02	0.01	1.00 - 1.04	0.70	0.01	0.68 - 0.72
	3	1.30	0.02	1.26 - 1.33	0.57	0.02	0.53 - 0.60
	4	1.66	0.05	1.57 - 1.76	0.50	0.03	0.45 - 0.55
	5	2.17	0.13	1.92 - 2.45	0.47	0.04	0.40 - 0.55
	6	3.36	0.41	2.64 - 4.28	0.51	0.07	0.39 - 0.68
Cohort	1960				0.48	0.03	0.43 - 0.53
	1961				0.47	0.02	0.42 - 0.52
	1962				0.50	0.02	0.45 - 0.55
	1963				0.54	0.02	0.50 - 0.59
	1964				0.55	0.02	0.50 - 0.59
	1965				0.57	0.02	0.53 - 0.62
	1966				0.63	0.02	0.59 - 0.67
	1967				0.69	0.02	0.65 - 0.74
	1968				0.72	0.02	0.68 - 0.77
	1969				0.83	0.03	0.77 - 0.88
	1970				1.00		
	1971				1.23	0.04	1.15 - 1.31
	1972				1.50	0.05	1.41 - 1.61
	1973				1.69	0.06	1.58 - 1.81
	1974				2.02	0.07	1.88 - 2.17
	1975				2.31	0.09	2.14 - 2.49
	1976				2.66	0.11	2.45 - 2.89
	1977				2.90	0.13	2.66 - 3.15
	1978				3.03	0.14	2.77 - 3.32
	1979				3.41	0.17	3.10 - 3.76
	1980				3.93	0.21	3.54 - 4.35
	1981				3.91	0.22	3.50 - 4.37
	1982				4.19	0.25	3.72 - 4.72

Table S6. Men born 1960-1982: within-family comparison results from analyses of the relationship between birth order and educational attainment at age 30 using fixed effect linear regressions.

		Bivariate			Adjusting for Birth Year		
Variable	Category	OR	SE	95% CI	OR	SE	95% CI
Birth Order	1	1.00			1.00		
	2	0.84	0.01	0.83 - 0.86	0.67	0.01	0.65 - 0.69
	3	0.91	0.01	0.89 - 0.94	0.55	0.02	0.51 - 0.58
	4	1.08	0.03	1.02 - 1.15	0.51	0.03	0.46 - 0.56
	5	1.31	0.09	1.15 - 1.49	0.50	0.04	0.42 - 0.59
	6	1.43	0.19	1.10 - 1.85	0.43	0.06	0.32 - 0.57
Cohort	1960				0.56	0.03	0.50 - 0.63
	1961				0.55	0.03	0.50 - 0.61
	1962				0.59	0.03	0.53 - 0.64
	1963				0.63	0.03	0.58 - 0.69
	1964				0.64	0.03	0.59 - 0.70
	1965				0.71	0.03	0.66 - 0.76
	1966				0.75	0.03	0.70 - 0.81
	1967				0.79	0.03	0.74 - 0.84
	1968				0.80	0.03	0.75 - 0.86
	1969				0.85	0.03	0.80 - 0.91
	1970				1.00		
	1971				1.07	0.04	1.00 - 1.14
	1972				1.24	0.04	1.16 - 1.32
	1973				1.36	0.05	1.27 - 1.45
	1974				1.37	0.05	1.28 - 1.47
	1975				1.53	0.06	1.42 - 1.65
	1976				1.73	0.07	1.60 - 1.87
	1977				1.57	0.07	1.45 - 1.71
	1978				1.75	0.08	1.60 - 1.91
	1979				1.92	0.09	1.75 - 2.11
	1980				2.22	0.11	2.01 - 2.46
	1981				2.23	0.12	2.01 - 2.49
	1982				2.40	0.14	2.14 - 2.69