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Original Article

The Production of Inequalities within Families and across Generations: The Intergenerational Effects of Birth Order on Educational Attainment

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Abstract

There has long been interest in the extent to which effects of social stratification extend and persist across generations. We take a novel approach to this question by asking whether birth order in the parental generation influences the educational attainment of their children. To address this question, we use Swedish population data on cohorts born 1960–1982. To study the effects of parental birth order, we use cousin fixed effects comparisons. In analyses where we compare cousins who share the same biological grandparents to adjust for unobserved factors in the extended family, we find that having a later-born parent reduces educational attainment to a small extent. For example, a second- or fifth-born mother reduces educational attainment by 0.09 and 0.18 years, respectively, while having a second- or fifth-born father reduces educational attainment by 0.04 and 0.11 years, respectively. After adjusting for attained parental education and social class, the parental birth order effect is practically attenuated to zero. Overall our results suggest that parental birth order influences offspring educational and socioeconomic outcomes through the parents own educational and socioeconomic attainment. We cautiously suggest that parental birth order may have potential as an instrument for parental socioeconomic status in social stratification research more generally.

Introduction

Research on the intergenerational transmission of status has a long history in the social sciences, and studies have consistently documented the importance of the family of origin for socioeconomic attainment (e.g. Sorokin, 1927; Blau and Duncan, 1967; Erikson and Goldthorpe, 1992; Ermisch, Jantti and Smeeding, 2012). Although the literature on stratification and social mobility provides strong evidence for intergenerational transmission of status, the intergenerational impact of demographic factors within the family on the educational and socioeconomic attainment of grandchildren has received much less attention (Mare, 2011).

To date, research on the intergenerational transmission of advantage has focused largely, if not exclusively,

on differences across families rather than within families. Although parental socioeconomic status and household income are powerful predictors of offspring attainment, sibling correlations on high school grades, educational attainment, and earnings in adulthood demonstrate that there are substantial differences in outcomes even amongst children who share the same parents (Conley, 2004; Björklund and Markus, 2012; Grätz *et al.*, 2019). These differences in sibling outcomes suggest that there are important inequality generating processes operating even within families, and that processes of cumulative advantage based upon differences in relative access to resources within the household can lead to substantial differences in outcomes in the long-run, and potentially even over subsequent generations.

In this study, we deploy three generations of population register data from Sweden to examine whether inequality-generating processes within families, such as differences in parental investment, have effects on the attainment of the subsequent generation. We address this question by examining whether birth order in the parental generational is associated with the educational attainment of their children. For example, we ask whether the first-born child of a first-born parent achieves greater educational attainment than the first-born child of a third-born parent. In order to estimate the effects of parental birth order net of shared family background factors, we apply cousin fixed effects based on maternal and paternal cousin groups. Research on birth order has been criticized on the grounds that it lacks policy relevance. However, the fact that birth order is essentially random and not amenable to policy intervention is a strength when it is considered as a random assignment to relative advantage in terms of resource access and parental investment during childhood. Moreover, to the extent that birth order effects work through parental investment mechanisms (admittedly an open question), they can inform policy discussions that focus on efforts to increase such household investments in children.

Birth Order and Attainment: Theory and Empirical Evidence

Research suggests that first- and earlier-born siblings are systematically advantaged over later-born siblings on many dimensions of parental care and investment both during pregnancy and during childhood (Zajonc and Markus, 1975; Zajonc, 1976; Blake, 1989; Buckles and Kolka, 2014) and that this leads to measurable differences in terms of educational and socioeconomic outcomes (e.g. see Black, Devereux and Salvanes, 2005a; Barclay, Hällsten and Myrskylä, 2017). Mothers are more likely to seek prenatal care for first-born children (Buckles and Kolka, 2014), they are more likely to breast feed first-borns (Buckles and Kolka, 2014), and they take longer periods of parental leave to spend with first-borns (Sundström and Ann-Zofie, 2002). Research in the United States indicates that parents regulate the television watching and monitor the school performance of first-borns to a greater extent than they do for later-born children (Hotz and Pantano, 2015). Studies also indicate that, particularly in middle class families, younger children can be hostages to the activities and schedules of older children, whose cultivation is prioritized by the parents over that of the younger children (Lareau, 2011). Parents spend more time with first-borns than later-borns, with some estimates suggesting that parents spend 20–30 minutes more quality time per day with first-borns than second-borns of the same age (Price, 2008).

A potentially important factor explaining the differences in parental time spent with children is structural change in the sibling group attributable to changes in family size, which leads to the dilution of parental resources (Blake, 1989). Parents have relatively more time for their first-born child during the early years of life than they have for later-born children, as parental time is finite, and family size is a time-varying factor during the life course. According to the resource dilution hypothesis, first-borns will typically be the most advantaged amongst a group of siblings precisely because they spend a period of time with exclusive access to parental attention and various other parental resources. Studies indicate that these early years can be crucial for child development. Although this has been shown most dramatically by examining severely deprived children (Rutter, 1998), it is also clear that early life investment has an important impact on reading ability and numeracy even amongst children who are not deprived (Stanovich, 1986; Bast and Reitsma, 1998; Sénéchal and LeFevre, 2002; Cheadle, 2008).

A second theory concerned with structural changes to the sibling group is the confluence hypothesis (Zajonc and Markus, 1975; Zajonc, 1976). The confluence hypothesis also posits that earlier-born siblings should be advantaged over later-born siblings, but argues that this is due to the average degree of intellectual stimulation in the household. First-borns interact exclusively with their parents, which is highly cognitively stimulating, until the subsequent birth of any siblings. This is presumed to be beneficial for cognitive development. Later-borns, however, interact not only with the parents but will also spend much time interacting with their other siblings, who may offer much less cognitive stimulation. This, in

turn, may evince negative long-term consequences on cognitive development. Indeed, studies show that later-born children have lower cognitive ability and educational attainment than first-borns (Black, Devereux and Salvanes, 2005a; Bjerkedal *et al.*, 2007; Barclay, 2015b).

As this body of theoretical and empirical research would suggest, there are also consistent birth order differences in academic achievement. Studies that have compared siblings within the same family have consistently shown that later-borns have a lower GPA than first- and earlier-born siblings (Kalmijn and Kraaykamp, 2005), are less likely to graduate from high school (Härkönen, 2014), or to go to university (Barclay, 2018), and have lower completed educational attainment (Black, Devereux and Salvanes, 2005a). In Sweden, second-borns, third-borns, and fourth-borns typically achieve around 30, 40, and 50 per cent of a year less education than first-borns by age 30, respectively (Barclay, 2015a).

Past work strongly suggests that these birth order differences in attainment are attributable to differences in how children are raised rather than any biological differences between siblings or differences in the *in utero* environment by parity. Studies on sibling groups where social and biological birth order differ, such as sibling groups where a child has died, or sibling groups of adopted children, show that it is social birth order that explains differences in attainment rather than biological order (Kristensen and Bjerkedal, 2007; Barclay, 2015a). Furthermore, it is worth noting that biomedical factors actually predict worse long-term outcomes for first-born children, who are more likely to be born with low birth weight (Kramer, 1987) and to be born pre-term (Astolfi and Zonta, 1999), both of which typically lead to worse long-term socioeconomic outcomes (Conley and Bennett, 2000; Black, Devereux, and Salvanes, 2007). Studies on birth order and academic attainment therefore not only suggests that the first-born and earlier-born advantage is attributable to differences in how children are raised but also that these differences in nurture are sufficiently great to overcome physiological disadvantages amongst first-borns at the time of birth.

Past research on birth order and educational attainment not only accounts for why later-born children should achieve lower educational attainment than first- and earlier-born siblings but also suggests that a child's later-born parents should have lower educational attainment than their first- and earlier-born aunts and uncles. Figure 1 provides a visual illustration of the theoretical process by which we argue parental (G2) birth order may influence grandchild (G3) educational and socioeconomic attainment. If parental educational attainment has an effect on the attainment of their children, then we would expect that the birth order of the index person's parents should matter for G3 educational attainment even net of the index person's own birth order. For example, the first-born child of a first-born mother should achieve higher levels of educational attainment than the first-born child of a third-born mother.

Parental birth order could be associated with offspring attainment for several reasons. First, there may be specific effects of parental birth order on parenting behaviour. Namely, if first-borns (for example) received more one-on-one, high quality interaction from their own parents, they may, in turn, see this form of parenting as normative and thus perpetuate it in the next generation to all their children. Conversely, those of higher parity that were raised in more of an 'accomplishment of natural growth model' (c.f. Lareau, 2011), may be more likely to adopt that approach to parenting when they become parents. Second, there may be an interaction between parental birth order and filial birth order such that parents identify with–and give more attention to–children who share their particular birth position (or parity-gender combination). Finally, there is the question of measurement error. To the extent that any statistical adjustment for measures of parental socioeconomic status do not capture the full downstream benefits of early parity for parents, there may be a residual effect of parental birth order on offspring.

Data and Methods

Data

In this study, we use Swedish population register data with multigenerational linkages to examine how birth order in the parental generation is related to educational attainment amongst their children at age 30. We examine educational attainment amongst Swedish men and women born between 1960 and 1982, whose parents were born between 1938 and 1969. In our analyses, we focus on families where both the parents and children were born in Sweden. In Sweden, each individual has a personal identity number (PIN) that enables records to be linked across a variety of administrative registers. The Swedish multigenerational register also contains information on the PIN of the mother and father of any given individual. Information on the PIN of the mother and father allows any given individual to be linked to any biological kin, including siblings, cousins, and grandparents (Table 1).

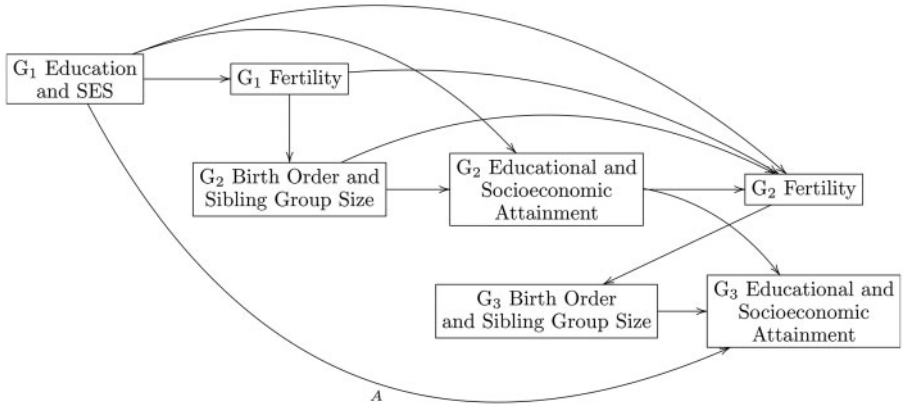

Figure 1. Theoretical illustration of the link from grandparent (G1) fertility to parental (G2) birth order and sibling group size to grandchild (G3) educational and socioeconomic attainment. We note that a direct link between G1 and G3 educational and socioeconomic attainment, labelled A, remains contentious in the literature

To examine the relationship between the birth order of parents and the educational attainment of their offspring, it is essential to have three generations of data. Information on the identity of the grandmother and grandfather [Generation 1 (G1)] is needed to identify the birth order of the parents (G2), while information on the fertility of the parents (G2) is need to identify the birth order of the grandchildren (G3). We classify a sibling group (G2 and G3) as a set of individuals who share a biological mother and father. A cousin group (G3) is based upon sharing a biological grandmother and grandfather. Figure 2 provides a graphical illustration of our data structure. Although we describe this in greater detail below, in the 'Statistical Analyses' section, a key dimension of our study is the use of a cousin fixed effects design, which has implications for our sample selection.

We compare cousins in order to reduce confounding from factors shared amongst parents, aunts, and uncles. These factors include grandparental socioeconomic status, which might affect both fertility behaviour as well as the educational attainment of the parental generation (G2), and which are unmeasured because of the early time period. This means that we exclude 'only cousins' from our analysis. An 'only cousin' might have multiple siblings, but not have any cousins within their own generation, either because their parents were only children or because their aunts and uncles did not have any children of their own. To be clear, that means that we exclude families where the parents (G2) were only children. In our analyses focusing upon birth order, we also exclude sibling groups at the G2 and G3 level which experienced a multiple birth such as twins, as this confuses the measurement of birth order.

The Swedish educational context

Education in Sweden is state funded at all levels, and tertiary education is free for Swedish citizens (Halldén, 2008; Högskoleverket, 2012). In Sweden, family resources are therefore less important for the transition to tertiary education than in other contexts, such as the United States. The Swedish education system is divided into three sections: (i) 9 years of compulsory schooling (*grundskolan*); (ii) three additional years of secondary school (*gymnasium*); and (iii) the tertiary section (Halldén, 2008). Tertiary education in Sweden today consists of two parts. The first is a traditional university education, with degrees at the Bachelors (*kandidatexamen*), Magister (*magisterexamen*), Masters, Licentiate, and Doctoral levels. The second part is a vocational tertiary education (högre yrkesutbildning/högskolor) (Halldén, 2008). 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), minimizing the need for reliance on family resources for maintenance. In 2012, approximately 33 per cent of the Swedish population had undergone post-secondary education, which was slightly higher than the OECD average (Högskoleverket, 2012).

Outcome variable

The primary outcome variable in this study is educational attainment in years, measured in the year that the index person turned 30. We use a seven-category variable provided by Statistics Sweden for levels of education and convert this to years of education as follows:

Table 1. Sample exclusion process

Sample	Exclusion stage	*N* included	*N* excluded
Full sample	Total men and women born in Sweden 1960–1982	2,436,457	
	ID available for both parents	2,405,975	30,482
	No multiple births	2,342,820	63,155
	All siblings born in Sweden	2,304,598	38,222
	ID available for grandparents	1,213,681	1,090,917
	No multiple births in parents generation	1,132,517	81,164
	Both parents born in Sweden	1,097,014	35,503
	All parents siblings born in Sweden	1,086,271	10,743
	Both mother and father born in 1938 or later	944,999	141,272
	No missing values on G3 educational attainment	907,908	37,091
	Final	907,908	
Maternal cousin sample	Total men and women born in Sweden 1960–1982	2,436,457	
	ID for both parents	2,405,975	30,482
	No multiple births	2,342,820	63,155
	All siblings born in Sweden	2,304,598	38,222
	ID for all four grandparents	1,213,681	1,090,917
	No multiple births in parents generation	1,132,517	81,164
	Both parents born in Sweden	1,097,014	35,503
	All parents siblings born in Sweden	1,086,271	10,743
	Both mother and father born in 1938 or later	944,999	141,272
	No missing values on G3 educational attainment	907,908	37,091
	No only cousins	509,739	398,169
	Final	509,739	
Paternal cousin sample	Total men and women born in Sweden 1960–1982	2,436,457	
	ID for both parents	2,405,975	30,482
	No multiple births	2,342,820	63,155
	All siblings born in Sweden	2,304,598	38,222
	ID for all four grandparents	1,213,681	1,090,917
	No multiple births in parents generation	1,132,517	81,164
	Both parents born in Sweden	1,097,014	35,503
	All parents siblings born in Sweden	1,086,271	10,743
	Both mother and father born in 1938 or later	944,999	141,272
	No missing values on G3 educational attainment	907,908	37,091
	No only cousins	514,222	393,686
	Final	514,222	

1. Pre-Gymnasium-level education shorter than 9 years (*Förgymnasial utbildning kortare än 9 år*).
2. Pre-Gymnasium-level education [*Förgymnasial utbildning 9 år (motsvarande)*], corresponding to 9 years of education in our outcome variable.
3. Gymnasium-level education of at most 2 years (*Gymnasial utbildning högst 2-årig*), corresponding to 11 years of education in our outcome variable.
4. Gymnasium-level education of 3 years (*Gymnasial utbildning 3 år*), corresponding to 12 years of education in our outcome variable.
5. Post-Gymnasium-level education shorter than 3 years (*Eftergymnasial utbildning kortare än 3 år*), corresponding to 14 years of education in our outcome variable.
6. Post-Gymnasium-level education 3 years or longer (*Eftergymnasial utbildning 3 år eller längre*), corresponding to 16 years of education in our outcome variable.
7. Research-based education (*Forskarutbildning*), e.g. PhD, corresponding to 20 years of education in our outcome variable.

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. Due to educational reforms in Sweden, in practice nobody in the G3 cohorts that we study (those born 1960–1982) has educational level 1 (primary education <9 years).

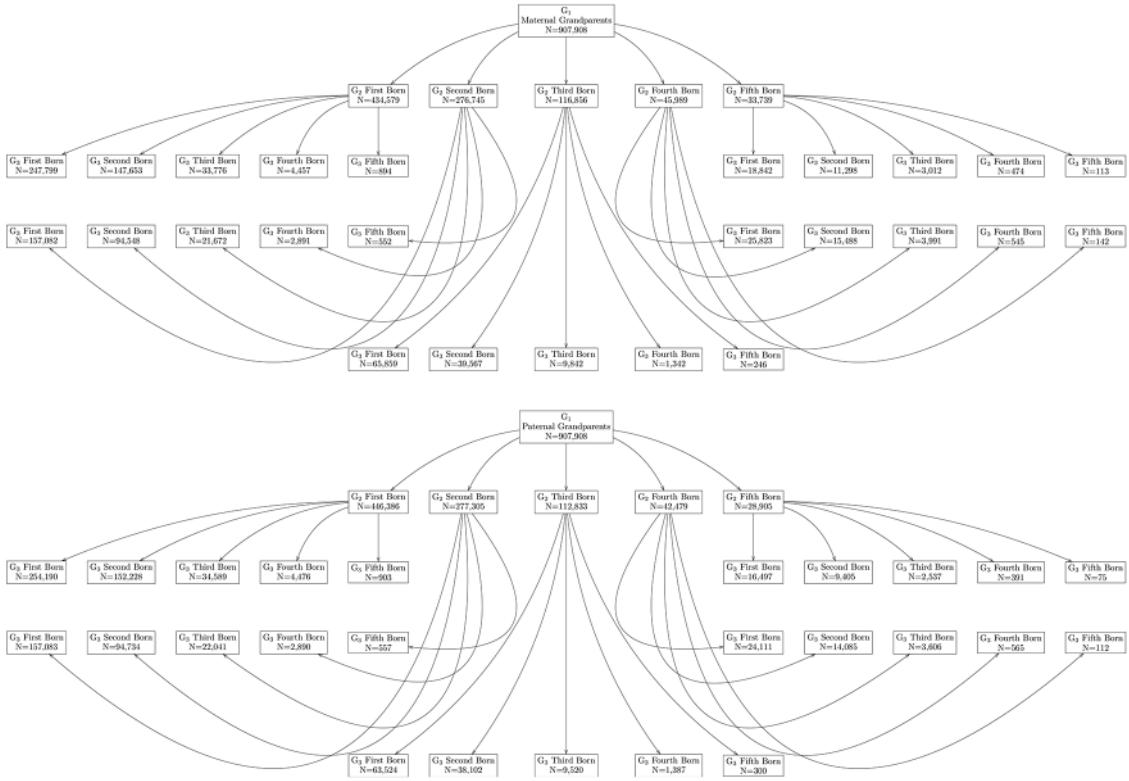

Figure 2. Multigenerational data structure

Control variables

We adjust for a number of different factors that are linked to parental (G2) and offspring (G3) birth order, and educational attainment. We adjust our analyses for maternal sibling group size (G2), paternal sibling group size (G2), grandmaternal age at the time of birth of the mother (G2), grandmaternal age at the time of birth of the father (G2), and maternal and paternal birth year (G2). These variables capture conditions at the time of birth, with the exception of parental sibling group size, which may be not settled until later childhood. We adjust for the completed sibling group size of the parents as there is a correlation between sibling group size and educational attainment (Black, Devereux and Salvanes, 2005a), and higher birth order siblings will be drawn from larger sibling groups. We adjust for grandparental age at the time of birth as later-born siblings are typically born to older mothers and fathers, and advanced parental age may be associated with educational outcomes (Barclay and Myrskylä, 2016). We control for the birth year of the parents (G2) in order to adjust for educational expansion over time (Breen *et al.*, 2009; Breen, 2010), which benefits later-born siblings and cousins relative to kin born in an earlier period (Barclay, 2018) (Table 2).

We also control for sociodemographic characteristics of the grandchild generation (G3), including the birth order of the index person (G3), the sex of the index person (G3), the sibling group size of the index person (G3), the birth year of the index person (G3), and maternal and paternal age at the time of the birth of the index person (G3). These factors may well be influenced by parental birth order, and are also known to influence educational attainment. Most important amongst these is the birth year of the index person (G3), as being born in a later calendar year during a period of rapid educational expansion is known to be associated with a higher average educational attainment (Breen *et al.*, 2009; Breen, 2010).

Mediator variables

We consider the educational and socioeconomic attainment of the parents as potential mediators for the relationship between parental birth order and offspring educational attainment. Our expectation is that the

Table 2. Variables included in statistical models

	Variables			
Variable category	Model 1	Models 2, 5, and 8	Models 3, 6, and 9	Models 4, 7, and 10
Explanatory	Maternal birth order	Maternal birth order	Maternal birth order	Maternal birth order
Explanatory	Paternal birth order	Paternal birth order	Paternal birth order	Paternal birth order
G2 Control		(Maternal sibling group size)	(Maternal sibling group size)	(Maternal sibling group size)
G2 Control		(Paternal sibling group size)	(Paternal sibling group size)	(Paternal sibling group size)
G2 Control		Maternal grandmother age	Maternal grandmother age	Maternal grandmother age
G2 Control		Paternal grandmother age	Paternal grandmother age	Paternal grandmother age
G2 Control		Maternal birth year	Maternal birth year	Maternal birth year
G2 Control		Paternal birth year	Paternal birth year	Paternal birth year
G2 Control			Index birth order	Index birth order
G2 Control			Sex	Sex
G2 Control			Sibling group size	Sibling group size
G2 Control			Birth year	Birth year
G2 Control			Maternal age	Maternal age
G2 Control			Paternal age	Paternal age
G2 SES Mediator				Maternal educational attainment
G2 SES Mediator				Maternal social class (EGP)
G2 SES Mediator				Paternal educational attainment
G2 SES Mediator				Paternal social class (EGP)

association between parental birth order and offspring educational attainment operates entirely through the educational and socioeconomic attainment of the parents. Although we are aware that studying mediation in intergenerational and multigenerational processes requires a number of assumptions, we prefer to include these analyses and discuss the potential biases and limitations rather than to omit those analyses (Breen, 2018). We evaluate mediation in our study by adjusting for the attained education and social class of the mother and father (G2). Maternal and paternal educational attainment is based upon the highest attained level of educational attainment. Highest maternal and paternal educational attainment is grouped into eight categories, which are: primary (<9 years), primary (9 years), secondary (10–11 years), secondary (12 years), tertiary (13–15 years), tertiary (15+ years), graduate school, and missing. Maternal and paternal social class is based upon the Erikson, Goldthorpe, and Portocarero (EGP) occupational class scheme (Erikson, Goldthorpe and Portocarero, 1979), measured between ages 30 and 40 using information on occupation from the Swedish censuses in 1960, 1970, 1980, and 1990.

The EGP variable used in this study is divided into the following categories: upper service class, including self-employed professionals (EGP=I); lower service class (EGP=II); routine non-manual (EGP=III); self-employed non-professionals, farmers, and fishermen (EGP=IV); skilled and unskilled workers (EGP=VI–VII); and, unknown/other.

Statistical Analyses

To examine the relationship between birth order and educational attainment at age 30, we use linear regression with and without the application of fixed effects. We first estimate the association between parental birth order and offspring educational attainment using the full sample, without implementing fixed effects:

$$y = \beta_0 + \beta_l BO_l + \varepsilon \quad 1)$$

$$y = \beta_0 + \beta_l BO_l + \beta_m G2Controls_m + \varepsilon \quad 2)$$

$$y = \beta_0 + \beta_l BO_l + \beta_m G2Controls_m + \beta_n G3Controls_n + \varepsilon \quad 3)$$

$$y = \beta_0 + \beta_l BO_l + \beta_m G2Controls_m + \beta_n G3Controls_n + \beta_o G2Mediators_o + \varepsilon \quad 4)$$

where y refers to years of educational attainment at age 30, BO refers to a vector of the birth order of the mother (G2) and father (G2), *G3-Controls* refers to a vector of the control variables at the level of the third-generation,

G2-Controls refers to a vector of the control variables at the level of the second-generation, and *G2-Mediators* refers to a vector of the G2 mediating variables, i.e. attained socioeconomic status and educational attainment of the parents. Model 1 estimates the total effect of maternal and paternal birth order on offspring educational attainment. Model 2 adjusts for confounding factors measured at the time of the parents' birth, and Models 3 and 4 successively introduce control variables for mediating variables at the G3 and G2 levels, respectively. Models 1–4 are OLS models that use the full population. Descriptive statistics for the population used to estimate Models 1–4 are shown in (Table 3).

Our fixed effects analyses are based upon a shared grandparental ID, meaning that we compare full biological cousins. Since an individual can have two sets of cousins, we have two analytical samples: maternal cousin groups, and paternal cousin groups. Our cousin fixed effects analyses are therefore based upon the following six models:

$$y_{ij} = \beta_0 + \beta_l BO_{l,ij} + \beta_m G2Controls_{m,ij} + \alpha_j + \varepsilon_{ij} \quad 5)$$

$$y_{ij} = \beta_0 + \beta_l BO_{l,ij} + \beta_m G2Controls_{m,ij} + \beta_n G3Controls_{n,ij} + \alpha_j + \varepsilon_{ij} \quad 6)$$

$$y_{ij} = \beta_0 + \beta_l BO_{l,ij} + \beta_m G2Controls_{m,ij} + \beta_n G3Controls_{n,ij} + \beta_o G2Mediators_{o,ij} + \alpha_j + \varepsilon_{ij} \quad 7)$$

$$y_{ik} = \beta_0 + \beta_l BO_{l,ik} + \beta_m G2Controls_{m,ik} + \delta_k + \varepsilon_{ik} \quad 8)$$

$$y_{ik} = \beta_0 + \beta_l BO_{l,ik} + \beta_m G2Controls_{m,ik} + \beta_n G3Controls_{n,ik} + \delta_k + \varepsilon_{ik} \quad 9)$$

$$y_{ik} = \beta_0 + \beta_l BO_{l,ik} + \beta_m G2Controls_{m,ik} + \beta_n G3Controls_{n,ik} + \beta_o G2Mediators_{o,ik} + \delta_k + \varepsilon_{ik} \quad 10)$$

where y refers to years of educational attainment at age 30, the indexes i, j, and k refer to individual i in maternal cousin group j, and paternal cousin group k, α is the fixed effect for maternal cousin group j, δ is the fixed effect for paternal cousin group k, and ε is the residual. Models 5–7 are linear regressions estimated on the maternal cousin analytical sample, implementing cousin fixed effects. Models 8–10 are linear regressions estimated on the paternal cousin analytical sample, implementing cousin fixed effects. As with the OLS models without cousin fixed effects (Models 1–4), we control for confounding variables measured at the time of the parents birth in Models 5 and 8, and introduce control variables for mediating variables at the G3 and G2 level, respectively, in Models 6, 7, 9, and 10. Further descriptive statistics for the maternal cousin and paternal cousin group samples are shown in Supplementary Appendices, in Tables S1 and S2.

Results

Between-Family Population Analyses

We begin by presenting the results from analyses of the relationship between parental birth order and the educational attainment of their children at age 30. Figure 3 shows the results from models using the full population of individuals for whom it was possible to link three generations using the Swedish register data, and do not implement the cousin fixed effects approach. Figure 3 consists of four panels, successively displaying the results from Models 1 to 4. These model numbers correspond to the equations detailed in 'Statistical Analyses' section. Full results tables for these models can be seen in Supplementary Appendices, in Table S3.

The results from Model 1 are the total effects of parental birth order, capturing all intermediary-mediating processes between parental birth and offspring educational attainment. The results from Model 1 show that, relative to having a mother who was first-born, having a mother who was third-born is associated with 0.07 less years of education by age 30, and having a mother who was fifth-born is associated with 0.33 less years of education at age 30. Likewise, having a father who was third-born is associated with 0.03 less years of education by age 30, and having a father who was fifth-born is associated with 0.27 less years of education at age 30. Introducing additional controls for parental (G2) characteristics in Model 2 actually increases the size of the point estimates. We see that, relative to having a first-born mother or father, having a mother or father who is second-born is associated with having approximately 0.20 years less education by age 30, and having a mother or father who is fifth-born or later is associated with having over 0.40 years less education by age 30. This change in the estimates between Models 1 and 2 is related to the fact that later-born parents were on average born into a later birth year, and as a consequence of educational expansion in Sweden they had more educational opportunities, with consequent benefits for their own educational achievement and subsequently the educational achievement of their children. By controlling for parental birth cohort in Model 2, we partially adjust for those period changes in educational opportunities.

In Models 3 and 4, we introduce additional covariates in order to control for variables at the grandchild level and the parental level. Model 3 focuses on control

Table 3. Descriptive statistics for birth order and educational attainment at age 30 for generation 3 (G3), Swedish men and women born 1960–1982

	Index birth order					Mother birth order					Father birth order				
	1	2	3	4	5+	1	2	3	4	5+	1	2	3	4	5+
N	515,405	308,554	72,293	9709	1947	434,579	276,745	116,856	45,989	33,739	446,386	277,305	112,833	42,479	28,905
Years of education															
Mean	12.9	13	12.9	12.6	12.3	12.9	13	12.9	12.7	12.6	12.9	13	12.9	12.7	12.6
SD	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.2	2.3	2.3	2.3	2.3	2.2
Mother birth order															
Mean	1.9	1.9	1.9	2	2	1	2	3	4	5.8	1.8	1.9	2	2	2.1
SD	1.2	1.2	1.2	1.3	1.3	0	0	0	0	1.2	1.1	1.2	1.2	1.3	1.4
Father birth order															
Mean	1.8	1.8	1.9	1.9	1.9	1.8	1.9	1.9	1.9	2.1	1	2	3	4	5.7
SD	1.1	1.1	1.1	1.2	1.2	1.1	1.1	1.2	1.2	1.3	0	0	0	0	1.1
Index birth order															
Mean	1	2	3	4	5.4	1.5	1.5	1.6	1.6	1.6	1.5	1.5	1.6	1.6	1.6
SD	0	0	0	0	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Index sibling group size															
Mean	2	2.4	3.3	4.4	6.1	2.3	2.3	2.4	2.4	2.4	2.3	2.3	2.4	2.4	2.5
SD	0.9	0.7	0.7	0.9	1.6	0.9	0.9	0.9	1	1	0.9	0.9	1	1	1.1
Index birth year															
Mean	1973.1	1974.6	1975.9	1976.5	1977.1	1973.7	1974	1974.1	1974.2	1974.4	1973.6	1974	1974.3	1974.5	1975
SD	5.6	5	4.6	4.5	4.4	5.5	5.4	5.3	5.3	5.1	5.5	5.4	5.3	5.3	4.9
Index mother age															
Mean	23.8	26.6	29.2	30.9	32.4	25.5	25.3	25	24.7	24.3	25.4	25.3	25	24.7	24.2
SD	4.1	3.8	3.8	4	4.1	4.4	4.4	4.4	4.3	4.2	4.4	4.4	4.4	4.4	4.2
Index father age															
Mean	26	28.7	31.3	33	34.5	27.4	27.5	27.4	27.2	27	27.6	27.4	27.1	26.9	26.5
SD	4.2	3.8	3.8	3.9	4.2	4.4	4.4	4.4	4.4	4.4	4.5	4.4	4.4	4.4	4.2
Mother sibling group size															
Mean	2.8	2.9	3.1	3.3	3.6	2.2	2.8	3.8	4.9	6.9	2.8	2.9	3	3.1	3.2
SD	1.6	1.6	1.7	1.9	2.2	1.2	1.1	1.2	1.2	1.8	1.6	1.6	1.7	1.8	1.9
Father sibling group size															
Mean	2.8	2.9	3.1	3.3	3.6	2.8	2.9	2.9	3	3.2	2.2	2.8	3.9	5	6.9
SD	1.6	1.6	1.7	1.9	2.1	1.6	1.6	1.7	1.7	1.9	1.2	1.2	1.2	1.4	1.8
Mother birth year															
Mean	1949.3	1948	1946.7	1945.6	1944.6	1948.2	1948.7	1949.2	1949.5	1950.1	1948.1	1948.7	1949.3	1949.8	1950.8
SD	5.4	4.8	4.3	4	3.7	5.3	5.1	5.1	5.1	4.8	5.2	5.2	5.1	5.1	4.9
Father birth year															
Mean	1947.1	1945.9	1944.6	1943.5	1942.6	1946.2	1946.5	1946.8	1947	1947.4	1946	1946.6	1947.1	1947.6	1948.6
SD	5.3	4.6	4.1	3.8	3.6	5.1	5	5	5	4.8	5	5	5	4.9	4.6

(continued)

Table 3. (Continued)

	Index birth order					Mother birth order					Father birth order				
	1	2	3	4	5+	1	2	3	4	5+	1	2	3	4	5+
Maternal grandmother															
Mean	28.2	28.4	28.5	28.4	28.2	25.9	29	31.4	33	35.1	28.3	28.3	28.2	28.2	28.1
SD	6.1	6.1	6.1	6.2	6.4	5.7	5.4	5.3	5.2	4.9	6.1	6.1	6.2	6.2	6.3
Mean	28.3	28.6	28.7	28.8	28.3	28.5	28.4	28.5	28.4	28.4	26.3	29.3	31.4	33	34.9
SD	6.1	6	6.1	6.2	6.3	6	6	6.1	6.2	6.2	5.7	5.4	5.3	5.1	4.8
Primary (<9 years)	9.4	10.7	14.5	21	31.5	9.2	10.5	12.1	14	15.3	10.5	10.2	10.5	11.2	10.3
Primary (9 years)	12	11.2	10.5	10.9	10.8	11	11.6	12.4	13.3	15.2	11.3	11.4	12.2	13.1	14.4
Secondary (10–11 years)	41.1	40.6	40	38.8	35.9	39.8	40.8	42.1	44	45.8	39.9	40.8	42	44.3	46.6
Secondary (12 years)	9.5	9.1	7.7	6.2	5.4	9.8	9	8.3	7.8	7.1	9.3	9.1	9.2	8.6	9.3
Tertiary (13–15 years)	12.6	12.5	11.3	9.3	7.3	13.1	12.6	11.5	10.1	8.8	12.7	12.7	11.9	10.5	9.6
Tertiary (15+ years)	14.8	15.3	15.5	13.4	8.4	16.6	15	13	10.3	7.6	15.8	15.2	13.8	12	9.6
Graduate school	0.5	0.5	0.5	0.4	0.3	0.5	0.5	0.4	0.3	0.1	0.5	0.5	0.4	0.3	0.2
Missing	0.1	0.1	0.1	0.1	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Mother EGP (per cent)															
I	1	0.8	0.7	0.6	0.7	1	0.9	0.8	0.7	0.5	1	1	0.8	0.7	0.5
II	35.4	38.7	36.7	31.5	25.1	39.4	36.7	32.5	28.4	24.2	39.4	36.3	32.1	28.4	23.3
III	9.8	7.8	5.8	5.4	5.7	8.5	8.8	9.2	9.4	8.7	8.5	8.9	9.2	9.2	9
IV	2.5	3	4.5	6.3	6.8	2.7	3	3.3	2.9	2.9	2.7	3	3.2	3.3	3
VI–VII	27.5	26	28	34	42.8	25.4	26.9	29.4	32.6	35.6	25.7	26.9	29.8	31.9	34.2
Unknown	23.8	23.7	24.3	22.3	18.9	23	23.6	24.9	25.9	28.1	22.7	24	25	26.5	30
Father education (per cent)															
Primary (<9 years)	18.1	20.3	25.2	31.9	38.8	18.8	19.3	20.7	22.6	24.6	17.6	19.8	22.5	26.5	27.7
Primary (9 years)	12.4	10.5	8.6	7.4	7.5	11	11.3	12	12.8	13.7	10.5	11.4	12.8	13.7	16.4
Secondary (10–11 years)	29.1	26.8	25.6	26.6	28.2	27.2	27.9	29.3	30.6	32.4	27.1	28	29.4	30.7	32.6
Secondary (12 years)	16.3	17.4	16	12.7	10.1	17.2	16.7	15.7	14.9	13.8	18	16.6	14.3	12.4	10.3
Tertiary (13–15 years)	10.5	10.5	9	6.9	4.5	10.6	10.4	9.9	9	8.2	11	10.3	9.3	7.9	7.2
Tertiary (15+ years)	12.1	12.9	13.4	12.1	8.9	13.5	12.7	11	8.9	6.6	13.8	12.5	10.4	8	5.1
Graduate school	1.3	1.5	2	2.2	1.8	1.6	1.4	1.2	0.9	0.5	1.7	1.3	1.1	0.7	0.5
Missing	0.3	0.2	0.1	0.2	0.3	0.3	0.2	0.3	0.3	0.2	0.3	0.2	0.2	0.2	0.2
Father EGP (per cent)															
I	1.8	1.5	1.1	0.8	0.9	1.7	1.7	1.5	1.2	1.1	1.7	1.7	1.4	1.2	1
II	21.3	23.7	22.7	18.9	15.3	23.6	22.4	20.1	17.9	15.3	24.9	21.9	18.1	14.5	10.9
III	3.1	2.2	1.3	1	1.1	2.6	2.7	2.7	2.5	2.5	2.5	2.7	2.7	2.8	2.6
IV	5.2	5.4	6.7	8.5	7.6	5.2	5.4	6	5.9	6.2	4.9	5.6	6.2	6.6	6.4
VI–VII	47.4	46.3	47.2	50.5	55	45.3	46.4	49.5	52.9	57.7	44	47.1	51.7	56.3	61.8
Unknown	21.3	21	21.1	20.3	20.2	21.7	21.5	20.2	19.6	17.2	22	21	20	18.7	17.3

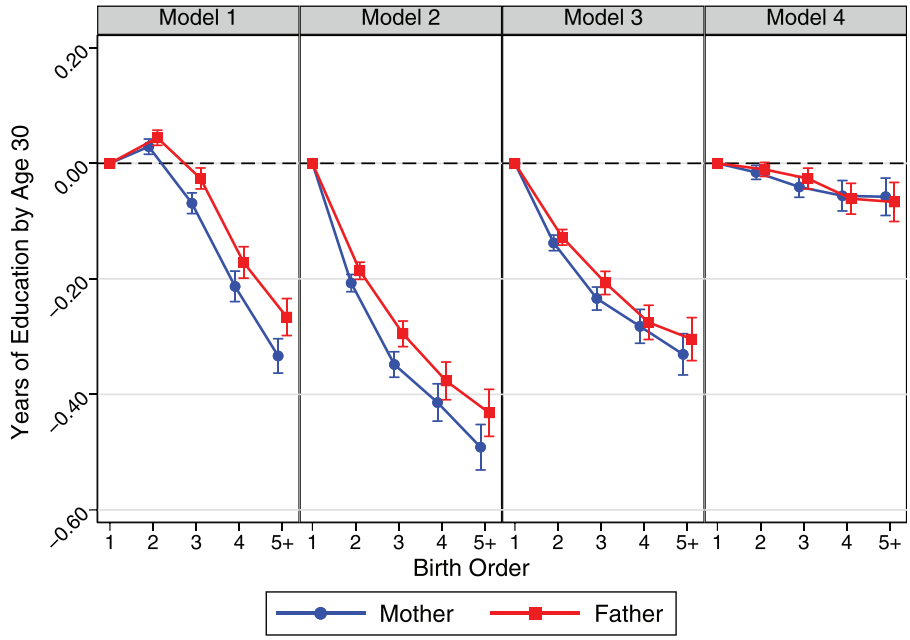

Figure 3. Educational attainment at age 30 amongst Swedish men and women born 1960–1982. Linear regression model, using maternal cousin sample. Error bars are 95 per cent confidence intervals

variables at the grandchild level. The results from Model 3 are relatively similar to those from Model 2, and we see that, relative to having a mother who was first-born, having a mother who was second-born is associated with 0.14 less years of education by age 30, and having a mother who was fifth-born is associated with 0.33 less years of education at age 30. Likewise, having a father who was second-born is associated with 0.13 less years of education by age 30, and having a father who was fifth-born is associated with 0.30 less years of education at age 30. Thus, even net of the index person's own birth order and birth year, amongst other factors, having a later-born parent is associated with lower educational attainment at age 30. Although even 0.30 years of education is not an enormous difference, it is comparable to estimates previously reported in the birth order literature (e.g. see Barclay, 2015a).

As we discuss earlier in this manuscript, we not only want to examine the association between parental birth order and offspring educational attainment, but also to examine the pathway by which that association operates. One possibility is that the effects of parental birth order are fully channelled through parental socioeconomic attainment. To examine this, we also introduce additional covariates for the highest level of educational attainment of the mother and father, as well as their attained social class position, measured between ages 40 and 50. As Figure 3 shows, when we control for parental educational and social class attainment, the association between parental birth order and offspring educational attainment is significantly attenuated. Relative to having a first-born mother or father, having a mother or father who is second-born is associated with having 0.01 years less education by age 30, and having a mother or father who is fifth-born or later is associated with having over 0.06 years less education by age 30. The results from Model 4 indicate that the effects of parental birth order are largely channelled through parental socioeconomic attainment. Furthermore, given measurement error in parental education, the effect of parental birth order net of parental educational and socioeconomic attainment may be zero. To investigate this question in greater detail, we now turn to our estimates using the cousin fixed effects approach. The fixed effects analyses will enable us to adjust for unobserved factors shared within the extended family that are not captured by the OLS estimator used in Models 1–4.

Cousin Fixed Effects Analyses

Figures 4 and 5 show the results from models where we implement a cousin fixed effects design, comparing cousins from generation 3 who share grandparents. Full results tables for these models can be seen in Supplementary Appendices, in Tables S4 and S5. Using

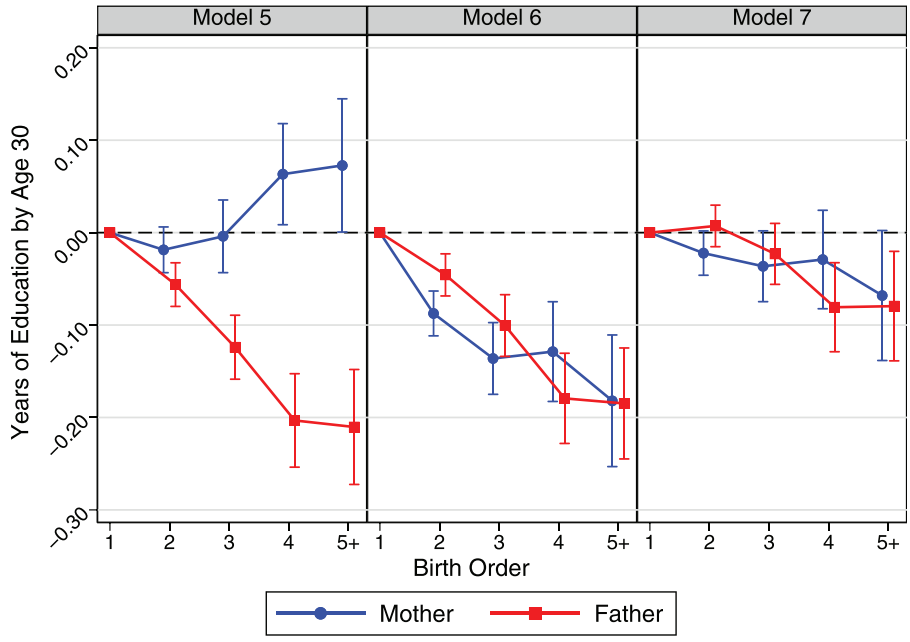

Figure 4. Educational attainment at age 30 amongst Swedish men and women born 1960–1982. Fixed effects linear regression model, using maternal cousin sample. Error bars are 95 per cent confidence intervals

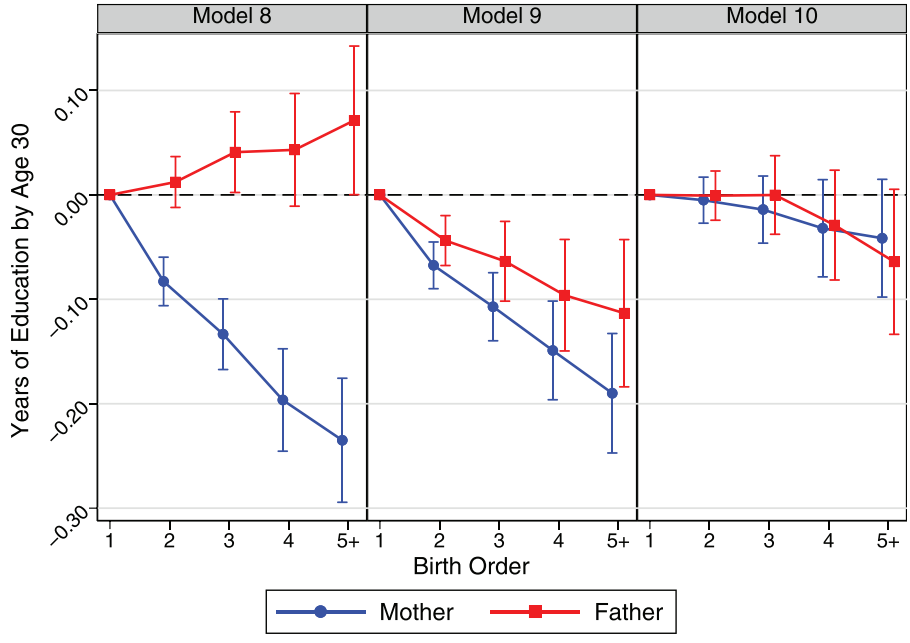

Figure 5. Educational attainment at age 30 amongst Swedish men and women born 1960–1982. Fixed effects linear regression model, using paternal cousin sample. Error bars are 95 per cent confidence intervals

this approach, we attempt to control for extended family background factors that may affect the attainment of the grandchildren many years later. Such background factors could include socioeconomic resources, as well as unobserved underlying health conditions within the family. Figure 4 shows the results from Models 5, 6, and 7, which are based on the maternal cousin group sample. Here, we focus on the point estimates for maternal birth order, since it is unobserved maternal background characteristics that are being effectively controlled for by comparing maternal cousins to one another.

Model 5 in Figure 4, controlling for factors fixed at the time of the parents birth, illustrates that the relationship between maternal birth order and offspring educational attainment is somewhat mixed, but the differences are generally not statistically significant. The only exception is that having a fourth-born mother is positively associated with offspring educational attainment. In Model 6, we introduce additional covariates for factors measured at the level of the index person (G3), or the grandchild generation. After controlling for G3 characteristics, most importantly birth year, we see that having a second-born mother relative to a first-born mother is associated with having 0.09 years less education at age 30, while having a fifth- or later-born mother relative to a first-born mother is associated with having 0.18 years less education at age 30. These estimates are smaller than those seen in Models 1–3.

In Model 7, we control for the attained educational and social class of the mother in order to examine whether effects of parental birth order flow only through their effects on parental educational and socioeconomic attainment. Here, we find that the effects of maternal birth order are attenuated more severely, and the estimated effects for maternal birth order are also no longer statistically significant. Overall these results indicate that children born to later-born mothers achieve lower educational attainment. However, the results from Model 7 indicate that the effects of parental birth order are largely channelled through parental socioeconomic attainment.

The reason for the difference in the estimates for maternal birth order between Models 5 and Models 6 and 7 is related to educational expansion as well as the cousin fixed effects approach. In the cousin fixed effects modelling approach, we create a mechanical relationship between birth order and birth year, where later-borns are almost always going to be born into a later birth year (this is completely deterministic in sibling FE model, but there is more potential for covariance in a cousin FE model focusing on parental birth order). When we control for G3 birth year, as we do in Model 6, we completely control away the benefits of educational expansion because G3 is the generation whose educational attainment we are actually measuring and who benefit directly from being born into a later birth year. By excluding a control for the birth year of G3 in Model 5 parental birth order captures secular trends in educational enrolment. As a result, the estimates from Model 5 indicate that later parental birth order tends to be associated with increasing educational attainment, but this is only because later-born parents are also more likely to give birth in a later calendar year than their older siblings, which then captures the increasing educational enrolment in Sweden in this period. In a period without educational expansion, Model 5 would almost certainly show a negative association between parental birth order and offspring attainment.

The results shown in Figure 5 repeat these analyses on the sample of paternal cousins, and here we focus on the association between the birth order of the father and offspring educational attainment. The results for paternal birth order from Models 8, 9, and 10 correspond relatively closely to the results for maternal birth order from Models 5, 6, and 7. In Model 8, we observe a positive, though non-statistically significant, association between paternal birth order and offspring educational attainment. As explained above, this is primarily due to educational expansion and the lack of a control for offspring birth year (G3). Although G3 sibling group size and parental age at the time of birth could also be mediators in the relationship between parental birth order and offspring educational attainment, the change in the estimates for parental birth order between Models 5 and 6, and Models 8 and 9, is driven by the adjustment for G3 birth year. In Model 9, we observe small associations, where having a second-born father relative to a first-born father is associated with having 0.04 years less education at age 30, and having a fifth- or later-born father relative to a first-born father is associated with having 0.11 years less education at age 30.

In Model 10, we introduce additional controls for the father's educational and social class attainment, and find that the effects of paternal birth order on offspring educational attainment are reduced almost to zero, and are no longer statistically significant. As with the results from Models 1–4 and 5–7, these results indicate that the effects of parental birth order are largely channelled through parental socioeconomic attainment.

We have also conducted a number of robustness checks to examine the sensitivity of our results to our statistical modelling choices. We have checked whether coding birth order according to being first-, middle-, or last-born leads to meaningfully different results, and it

does not. We have also recoded birth order according to a first- versus later-born dichotomy, and this does not affect the conclusions that we would draw either. We have also estimated models using a more detailed control for parental birth year, using individual-year dummy variables rather than the cohort groupings used in the main models above. Those models also produce extremely similar results to those presented above. The detailed output from these additional analyses is available upon request.

Interaction between Parent Birth Order and Offspring Birth Order

We have also conducted a number of supplementary analyses to examine whether the interaction between parent and offspring birth order is associated with educational attainment beyond the additive contributions of parent and offspring birth order. If parents identify with, and give more attention to, offspring who share their particular birth position, then this might benefit those children. However, these analyses do not suggest any interactions that are statistically significant or substantive in magnitude, even when we examine shared birth order position and gender between the parent and child (e.g. first-born daughter of a first-born mother). These results are available upon request.

Supplementary Analyses

In additional analyses, we have examined whether the patterns that we observe persist if we use a less restrictive sample selection process, basing the sample only upon maternal and grandmaternal fertility, and conditioning only upon the availability of information on the maternal grandmother. The results from those analyses are extremely similar to the main results presented above. The sample exclusion process for those analyses can be seen in Supplementary Table S6, and the results seen in Supplementary Figures S1 and S2.

Some previous research suggests that birth order patterns differ by family socioeconomic status (e.g. Barclay, Hällsten and Myrskylä, 2017). To test this, we examined whether parental birth order was more strongly associated with offspring attainment amongst those parents who were raised in a high SES (EGP categories I and II) or a lower SES (EGP categories III and below) family, based upon data for grandparental social class. In OLS models without cousin fixed effects, we find that parental birth order is more strongly associated with offspring attainment amongst parents from high EGP families, but that this disappears after adjusting for parental attained SES. Furthermore, in cousin comparison models the differences by grandparental EGP are neither clear nor consistent. The results from these additional analyses can be seen in Supplementary Figures S3–S6.

In further robustness checks, we have examined whether controlling for grandparental age at the time of birth of the grandchildren affects the association between parental birth order and offspring educational attainment, but this does not make a meaningful difference to the results. Those results can be seen in Supplementary Figures S7–S9. We have also estimated additional cousin fixed effects models where we do not control for the educational and socioeconomic attainment of the non-focal parent; those results do not differ from those presented above, and can be seen in Supplementary Figures S10 and S11.

We have also run additional analyses where we substitute our outcome variable for years of education for attainment of any tertiary education (i.e. post-Gymnasium qualifications equivalent to categories to 5, 6 or 7 in the educational categories described above) as a binary outcome variable. The results from those linear probability models, with the specification corresponding to Models 1–10 presented above, can be seen in Supplementary Figures S12–S14. Qualitatively speaking, those results are very similar to that presented above.

Discussion

In this study, we have used a remarkable multigenerational population dataset in order to examine whether family demographic factors, in this case parental birth order, have any effect on the educational attainment of subsequent generations. Since birth order can be considered a quasi-random assignment to parental investment, our study is able to get at the causal effect of within-family differences in grandparental care and investment for the parental generation and how this may or may not influence the subsequent generation. We find that parental birth order is indeed associated with the educational attainment of the grandchild generation.

The results from our models where we do not account for unobserved confounding shows that the negative effect on years of education by age 30 of having a second-born mother or father is around 0.14 years, and the negative effect of having a fifth-born mother or father is around 0.30 years. In our analyses where we compare cousins who share the same biological grandparents to adjust for unobserved factors shared in the extended family, we find that having a second- or fifth-born mother reduces educational attainment by 0.09 or 0.18 years, respectively, while having a second- or fifth-

born father reduces educational attainment by 0.04 or 0.11 years, respectively. To put these point estimates in perspective, the differences in educational attainment by comparing EGP class I to EGP classes VI–VII of the mother or father in our estimates is ≈0.30 years in Model 4. Thus, the estimated effects of having a second-born parent in our OLS models are approximately half of these EGP differences, and the estimated effects of having a fifth-born parent in our OLS models are similar to these estimated EGP differences. Nevertheless, it is important to acknowledge that even 0.30 years of education by age 30 is not an enormous difference. These associations are also smaller than those estimated for the index person's own birth order; for example, using data on these same cohorts Barclay (2015a) reported that second-borns have 0.28 fewer years of education compared to first-born siblings, while third-, fourth-, and fifth-borns had 0.43, 0.52, and 0.61 fewer years of education by age 30, respectively.

Further analyses show that the association between parental birth order and offspring attainment is largely attenuated after accounting for the attained education and socioeconomic status of the parents measured in later adulthood, which suggests that the effects of parental birth order on offspring attainment flows almost completely through the educational and socioeconomic attainment of the parents. This concurs with a recent study, based on the same data as ours, examining the effects of the attainment of grandparents on the attainment of children, that found that once models included detailed controls for parents' SES measures, grandparent effects were completely unimportant (Engzell, Mood and Jonsson, 2020). Nevertheless, it is important to be cautious about interpreting the results from these analyses that include mediating variables (Baron and Kenny, 1986; MacKinnon, Fairchild and Fritz, 2007; Heckman, Pinto and Savelyev, 2013). In research based upon observational data, analysis of mediation can introduce new sources of bias, for example from collider variables (Breen, 2018). For example, parental (G2) socioeconomic attainment is a collider variable in our design, even if attained before G3 is born, and when we condition on that variable we open up the possibility for confounding by uncontrolled or unmeasured factors that may jointly influence both parental SES attainment as well as G3 educational attainment; shared neighbourhoods are a concrete example of such a factor (Breen, 2018). Conceptually (if not in practice, as our robustness checks show), it is probably even worse to control for the SES of the 'other' parent in the cousin FE analyses (e.g. father SES when we conduct a maternal cousin comparison), because that opens the door to a multitude of factors that we do not adjust for (e.g. genes, values, resources on the 'other side' of the family). More generally, our estimates are likely to suffer from some sort of omitted variable bias despite our efforts to carefully adjust and to consider a wide range of potential models, and any analysis of multiple generations necessarily conditions on numerous important variables that include both survival to a certain age, as well as fertility, that necessarily introduces selection effects.

To the extent that we can rely upon our estimates from the models that include adjustment for parental educational and socioeconomic attainment, measurement error in parental attainment measures does not leave a large residual effect of parental birth order, contrary to one of our putative mechanisms. Indeed, to this end our study suggests that researchers might consider exploring the potential of parental birth order as an instrument for parental educational and socioeconomic attainment, since its effects on the subsequent generation flow clearly through that attainment channel.

It is worth noting that our findings present themselves in Sweden, which has comparably speaking, low levels of inequality, a strong welfare state that supports its neediest citizens, and a free educational system, including tertiary education. Thus, we expect that the intergenerational birth order effect that we observe in this study would be at least as likely to present itself in other countries whose social and political architecture exacerbates intergenerational inequality to a greater extent than in Sweden, and where rates of social mobility may be lower. However, it is worth also mentioning the specificity of the macro-demographic conditions in the period over which we study these intergenerational effects. Although total fertility was declining during this period, it was higher than today, attributable to lower levels of fertility control. Even though birth order was clearly a notable determinant of educational attainment within each generation, it is possible that birth order effects will become stronger over time as parents spend more time with children, focus even greater attention on quality over quantity, and practice longer birth spacing, as parental investment during the earliest years of life seems to be an important factor driving the birth order effect.

More generally, our study has the potential to shed light on the literature on the intergenerational effects of parental education on offspring educational attainment. Studies have generally used one of three different study designs to estimate the causal impact of parental education on offspring education: twin studies, adoption studies, and instrumental variables. Twin studies on this topic exploit differences in educational attainment

between identical (monozygotic) twins, and examine educational attainment amongst their children. These studies, using data from the United States, Denmark, and Norway, have consistently shown a positive effect of paternal education on offspring educational attainment, but rarely a positive effect of maternal education (Behrman and Rosenzweig, 2002; Antonovics and Goldberger, 2005; Hægeland *et al.*, 2010; Pronzato, 2012). Using twin difference models is problematic, however, given concerns about unobserved differences driving the twin discordance in education also driving the ultimate outcome among the twins' offspring (i.e. an exclusion restriction violation). Meanwhile, research examining how parental educational level influences the educational attainment of adopted children, using data from the United States, Norway, and Sweden, typically shows that both maternal and paternal levels of education matter for adoptee attainment (Dearden, Machin and Reed, 1997; Plug, 2004; Björklund, Lindahl and Plug, 2006; Sacerdote, 2007; Hægeland *et al.*, 2010). Studies using compulsory school reforms as an instrument to investigate whether parental educational attainment effects offspring educational have shown that in the UK and Norway greater maternal education increases education amongst the offspring, while greater paternal education does not have a significant effect (Chevalier, 2004; Black, Devereux and Salvanes, 2005b). However, a study using data on compulsory school reforms from the United States has shown that both maternal and paternal education matter for offspring attainment (Oreopoulos, Page and Stevens, 2006). While these studies do consistently find that parental educational level does exert a small effect on the educational attainment of their children, there are inconsistencies in whether it is the mother's or the father's education that matters the more. If, as we argue, parental birth order may have the potential to be used as an instrument for parental educational attainment, our study suggests that both maternal and paternal educational levels matters for offspring educational attainment, but that maternal educational level matters slightly more. This is consistent with a broader literature that demonstrates the importance of parental educational levels, but particularly maternal educational level, for the developmental trajectories of children (e.g. Kalil, Ryan and Corey, 2012).

Although the cousin fixed effects analyses that we employ are a powerful tool for adjusting for unobserved heterogeneity at the level of the extended family, there are doubtless limitations to these analyses. For example, these analyses do not adjust for factors that vary over time unless those variables are explicitly controlled for. Changes to grandparental occupation, income, or wealth over time could have affected the educational and socioeconomic attainment of parents and grandchildren. Although we can partially adjust for such factors by controlling for birth year of the parents and children, this is an imperfect solution. A further limitation is that within-family comparisons have also been shown to be more susceptible to bias from *non-shared* confounders than unpaired estimates, and within-family estimates are also biased towards zero even in the absence of confounders (Frisell *et al.*, 2012). More generally, cousin comparisons are likely to be less effective at adjusting for unobserved factors than are sibling comparisons because there is much more potential heterogeneity over time and within each G2-G3 family unit that is not captured by these cousin comparisons. Furthermore, our fixed effects analyses only adjust for shared factors on either the maternal or paternal side of the family in each analysis, allowing the possibility that unobservable factors on the other side of the family may introduce some form of confounding. Nevertheless, if interpreted with caution, these fixed effects models are a useful tool for answering our research question.

In conclusion, we find that parental birth order matters, albeit indirectly, for offspring educational and labour market attainment net of the child's own birth order. This intergenerational birth order pattern suggests that differences in grandparental investment between siblings in the parental generation matters not only for their own educational attainment, but that this also has spillover effects into the subsequent generation due to the effects on parental educational and socioeconomic attainment. Thus, we observe the production of inequalities within families and across generations, an all the more remarkable finding since we are able to adjust for unmeasured confounding by comparing full cousins who share the same biological grandparents. Differences in parental investment (or grandparental investment) within a family are naturally much smaller than the differences in parental investment that are observed between different families, and our study therefore highlights just how important parental investment is for offspring attainment, and how this has the potential to accumulate over subsequent generations.

Due to the temporal limitations of the Swedish population data we have focused on birth order effects across two generations, but if the additive effects of birth order on attainment persist in future generations then we can speculate that the educational and socioeconomic disadvantages of being a later-born may accrue over time. Thus, being a descendant of the 'first-born line' of a family over many future generations may lead to large

differences in life circumstances compared to being a descendant of the 'last-born line' of a family. Given that birth order differences were even more extreme in the past due to the practice of primogeniture, it is also likely that this long-term multigenerational process has produced notable differences in socioeconomic circumstances within extended families today.

Supplementary Data

Supplementary data are available at *ESR* online.

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