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Sibling Configurations, Educational Aspiration and Attainment

Feifei Bu
Institute for Social and Economic Research
University of Essex

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Non-technical Summary

Studies of inequality in education have focused mainly on differences between families, arising from disparities in (for example) parental education and social class. But educational disparity may also exist within families. Extensive empirical evidences suggest that firstborns have an educational advantage over their later-born counterparts. Despite the volume of literature in this area, the debate over birth order effects remains unresolved, due partly to criticisms about the types of data and the analytic methodologies employed. Although birth order is clearly a within-family phenomenon, most previous studies are based on cross-sectional data and standard regression models, which arguably may lead to overestimates of the birth order effect because of unmeasured confounding variables. As a consequence, it is argued that the clearly observed birth order effect may be nothing but a 'methodological illusion'.

The present study aims to shed light on this debate by examining birth order effects on educational attainment under a within-family design. We use sibling data from the British Household Panel Survey (BHPS), containing 1503 sibling clusters and 3552 individuals. Our analysis is based on multilevel modelling, which allows us to examine both within- and between- family variances, as well as intra- and cross-level interaction terms. Our results show that the birth order effect on education persists under the within-family design.

A second contribution of this paper is that we also study the role of birth order in the formation of adolescents' educational aspirations. In common with previous empirical studies, our results show that firstborns tend to achieve higher educational levels than their later-born counterparts. Moreover, we find the advantage of firstborns in educational outcomes may be partially explained by the fact that firstborns tend to have higher aspirations which push them toward higher educational levels. We also examine the effects of other aspects of sibling configuration, namely sibship size, age spacing and sex composition. Although females tend to have higher levels of educational aspiration and attainment, we find no evidence that the sex of one's siblings has any effect on educational aspiration or outcomes. Nor do we find a strong relationship between sibship size and either educational aspiration or attainment. But our results do show a significant positive effect of age spacing on individuals' educational attainment.

Sibling configurations, educational aspiration and attainment

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Abstract

Previous studies have found that firstborn children enjoy a distinct advantage over their later-born counterparts in terms of educational attainment. This paper advances the state of knowledge in this area in two ways. First, it analyses the role of young people's aspirations, estimating the effects of sibling configurations on adolescents' educational aspirations, and the importance of these aspirations on later attainment. Second, it employs multilevel modelling techniques, using household-based data which include information on multiple children living in the same families. The paper finds that firstborn children have higher aspirations, and that these aspirations play a significant role in determining later levels of attainment. We also demonstrate a significant positive effect of age spacing on educational attainment.

Keywords: birth order, educational aspiration, educational attainment, multilevel, MCMC

JEL Classification: C11, J13, J24

Contact Details: Feifei Bu, ISER, University of Essex, Wivenhoe Park, Colchester, UK, CO43SQ. Email: fbu@essex.ac.uk Tel: (01206) 874199

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1. Introduction

Studies of inequality in education have focused mainly on differences between families, arising from disparities in (for example) parental education and social class. But educational disparity may also exist within families: an extensive literature finds that firstborns have an advantage over their later-born counterparts (e.g. Behrman & Taubman, 1986; Booth & Kee, 2009). Despite the volume of literature in this area, the debate over birth order effects remains unresolved, due partly to criticisms about the types of data and the analytic methodologies employed. Although birth order is clearly a within-family phenomenon, most previous studies are based on cross-sectional data and standard regression models. This may lead to overestimates of the birth order effect because of unmeasured confounding variables; Rodgers et al (2000) find that the relationship between birth order and intelligence, so clearly observed in between-family research designs, is a methodological illusion, which disappears in within-family designs.

The present study aims to shed light on this debate by examining birth order effects on educational attainment under a within-family design. We use sibling data from the British Household Panel Survey (BHPS), containing 1503 sibling clusters and 3552 individuals. Our analysis is based on multilevel modelling, which allows us to examine both within- and between- family variances, as well as intra- and cross-level interaction terms. Our results show that the birth order effect on education persists under the within-family design.

A second contribution of this paper is that we also study the role of birth order in the formation of adolescents' educational aspirations. While aspirations have been shown to have a significant influence on later educational attainment (Jacob & Wilder, 2010; Marjoribanks, 2003) few studies have systematically addressed how family structures are related to the formation of aspirations. By addressing this question, we find that birth order has an effect on educational attainment not only directly, but also indirectly, via an indirect effect through aspiration. We also examine the effects of other aspects of configuration, namely sibship size, age spacing and sex composition. Although females tend to have higher levels of educational aspiration and attainment, we find no evidence that the sex of one's siblings has any effect on educational aspiration or outcomes. Nor do we find a strong relationship between sibship size and either educational aspiration or attainment. But our results do show a significant positive effect of age spacing on individuals' educational attainment.

The remainder of the paper is organized as follows: Section 2 provides a review of relevant theories and empirical studies. Data and methods are discussed in sections 3 and 4; Section 5 presents our results, and section 6 concludes.

2. Literature

2.1 Theoretical background

Several theoretical explanations have been advanced for observed differences in education by birth order. One of the most influential is the confluence theory, which was established by the psychologist Zajonc and his colleagues (Zajonc & Markus, 1975; Zajonc et al., 1979). The basic idea of this theory is that children's intellectual development is moulded by the intellectual environment in the family, which is a function of the average of the intellectual levels of all members of the family. It is assumed that an individual's intellectual level (maturity) is roughly proportional to his or her age; therefore, the intellectual environment in the family is higher for firstborns than their later-born siblings, since the intellectual level in the family will be diluted by new-borns. Since children cannot be as mature as parents, the greater the sibship size, the 'worse' the intellectual environment would become. Moreover, this theory also implies that families with narrower age spacing tend to be worse off.

Sibling dissimilarities have also been explained by differences in parental investment, such as material resources and parental time. This theory assumes that parental resources are limited and that children who receive more investment tend to excel intellectually and academically. The most obvious implication of this theory is that individual from larger families would be worse off since resources are diluted. Key to this question is how these resources are distributed among siblings in the same family. According to the family maximization model (Becker & Tomes 1976, 1979), parents tend to maximize the total achievements among their offspring. As discussed by Hanushek (1992), in order to achieve this, different parents might choose different investment strategies. For instance, parents may be egalitarian and subdivide their resources equally among their offspring; or they may invest more on the most able one, especially when their resources are rather limited; or they may allocate more resources to the less able child to compensate for his or her disadvantage. In practice, it is not clear which strategy is most commonly employed by parents. If we assume that parents in modern society tend to employ a more or less non-discriminatory strategy, as argued by Hertwig et al. (2002) the cumulative share of resources would still differ for children of different birth orders simply due to the sequential nature of their birth position. It puts firstborns in a favourable position since they experience a period of exclusive parental investment, time and attention. For instance, Price (2008) found that firstborns in a two-child family receive 20 to 30 more minutes of quality time engaging with their parents each day, comparing to lastborns with similar backgrounds. Of course, lastborn children have the opportunity to be the only child in the family when their older siblings have moved out. This, however, happens at a late development stage when certain parental investments are arguably less important.

More recently, Sulloway (1996, 1999, 2001, 2007) has poposed theories developed from the evolutionary perspective. He views children as active players in the family, and argues that human beings are essentially the same as other species, in that siblings growing up in the same family compete for parental favour and investment to secure their own needs. Based on Darwin's (1859) theory, he argues that siblings tend to maximize their differences in various ways in order to avoid direct competition and to make it more difficult for parents to compare their offspring. Thus, they tend to adopt different roles and develop different specialties in the family; for instance, a child with an academically successful older sibling may express his or her uniqueness in other ways, such as in the areas of art and sports.[1] The advantage of being the firstborn is that one is able to choose one's 'niche' first, without reference to the roles already adopted by other siblings.

Sulloway also argued that in reality birth order effects may be reinforced by stereotypes relating to birth order. For instance, Herrera et al. (2003) found that firstborns were widely believed to be more intelligent and attain higher occupational prestige, which may practically influence the actual role of birth order through parental expectation or self-fulfilling prophecy.

2.2 Empirical studies

2.2.1 Birth Order

According to the confluence theory (Zajonc & Markus, 1975; Zajonc et al., 1979) discussed above, we should expect firstborns to be on average more intelligent than laterborn children. Although this theory is supported by some empirical findings (e.g. Belmont & Marolla, 1973; Zajonc, 1976), these studies have been criticized for their methodological flaws, for example using between-family design to infer within-family dynamics (Rodgers, 2001; Rodgers, et al., 2000). Researchers (e.g. Kanazawa, 2012; Rodgers, et al., 2001; Wichman et al., 2006) using within-family designs found no significant relationship between birth order and intelligence.

1 This is similar to what Alderians called 'striving for significance'.

However, the debate was not resolved. Using a large Norwegian dataset, Black et al. (2011) found strong birth order effects on intelligence, with laterborn children tending to have lower IQ than their early-born counterparts, in both between- and within-family design.

By contrast, empirical studies estimating birth order effects on educational performance or attainment have yielded more conclusive results. Several well-designed studies have been carried out, employing large samples, controlling for familial confounders, and making efforts to disentangle the effects of birth order from the effects of sibship size. Behrman and Taubman (1986) investigate the impact of birth order on years of schooling for US adults. Using birth order as a continuous variable, they find that each higher rank in birth order was associated with a significant decline in years of schooling, with the effect relatively stronger for females. Using data from British Household Panel Survey (BHPS), Booth and Kee (2009) also found a negative birth order effect on individual's educational level. Iacovou (2008) examined birth order effects on children's educational performance at school in the UK, finding that laterborn children perform less well in academic tests at age 7 and age 12 than their firstborn counterparts.

These studies are still subject to the criticism that they infer within-family effects based on between-family analytic approaches. More recently, researchers have employed within-family designs. Black et al. (2005), using data that cover the entire Norwegian population, found a negative relationship between birth order and educational attainment; these results persisted when a fixed effects model was used. Similar results were also found by Bagger et al. (2013) using Danish data, Kristensen and Bjerkedal (2010) using Norwegian data, Kantarevic and Mechoulan (2005) based on data from the Panel Study of Income Dynamics (PSID), and Kalmijn and Kraaykamp (2005) using Dutch data. Hotz and Pantano (2013) provided empirical evidence that the firstborn advantage in educational performance holds when family fixed effects model was employed. We discuss the advantages and drawbacks of these fixed effects models later in the paper.

2.2.2 Other sibling structures

Studies that investigate the effects of sibship size generally find a negative relationship between the size of sibship and individuals' educational success, even after controlling for family background variables (e.g. Blake, 1981; Iacovou, 2008; Kuo & Hauser, 1997; Powell & Steelman, 1993). Sibship size is an important consideration in the study of the effects of birth order, because children who have a high position in the birth order are more likely to come from households with more children. Therefore it is essential to control for sibship size when birth order is under scrutiny, and vice versa. This is one of the most serious flaws that some birth order studies have been been criticized for - observed birth order effects in these studies could be spurious, due to a failure to control properly for the sibship size effect.

Sibship density or age spacing refers to the age difference between adjacent siblings in the same family. According to the confluence theory reviewed above, the intelligence climate is related not only to one's birth order in the family but also to the sibship density or age spacing between siblings. To illustrate, consider two children, both the later-born in a family of two: the child with a sibling six years older is theoretically in a more favourable intellectual environment than the child with a sibling who is only one year older. Further, if siblings are more widely spaced, parents can better spread their resources from the investment perspective. Therefore, it is expected that siblings would benefit from wider spaced sibships. The empirical evidence on this is rather limited; but Powell and Steelman (1990, 1993) in their analysis of American data, did find that close age spacing tends to increase the likelihood of high school dropout and decrease the likelihood of attending post-secondary school.

Intra-familial educational resources may also be differentially distributed within the family, because of the sex of the children, for example, parents who believe that the returns to education are higher for men may invest more heavily in their sons than in their daughters. Empirically, Powell and Steelman (1989) found that having brothers has a greater negative influence on getting financial support from parents for college students, while Butcher and Case (1994) found that women with only brothers tend to have higher education than women who grew up with any sister. However, other studies (e.g. Kaestner, 1997; Kuo & Hauser, 1997) found little empirical evidence for the sex composition effect on educational attainment.

3. Data: the British Household Panel Survey

The British Household Panel Study (BHPS) is a household-based panel survey which was conducted annually from 1991 (Wave 1) to 2008 (Wave 18) on a nationally representative sample of more than 5000 households, containing around 10,000 individuals in the first wave. Sample households were selected using an approximately equal-probability clustered and stratified design from the Postcode Address File (PAF) for Great Britain. Additional samples from Scotland, Wales and Northern Ireland were added to the original sample in later waves (Taylor et al., 2010).

In the main sample of the BHPS, referred to in this paper as the "adult panel", all members of sample households aged 16 or older were interviewed annually. From Wave 4 (1994) onwards, the BHPS was supplemented by a questionnaire administered to adolescents aged 11-15 in eligible sample households. This youth sample, known as the British Youth Panel (BYP), is effectively a rotating panel, representing young people growing up in the UK in the 1990s and 2000s[2]. The youth survey was conducted via a self-completion questionnaire which covered a range of topics including parent-child relationships, attitudes, health, psychological well-being, and, most relevant for the present study, their educational aspirations. When the youth sample members reached the age of 16, they left the BYP and became members of the adult panel, which makes it possible to track their later educational progress.

In 2009, the BHPS was replaced with a new, larger survey called the UK Household Longitudinal Study (UKHLS). This new survey incorporated the BHPS sample from 2010 onwards. In order to maximize the number of usable observations in the sample, data on the original BHPS sample from the 2010 UKHLS were used as the 19th wave of the BHPS.

3.1 Dependent variables: educational aspiration and attainment

Young people's educational aspirations are measured by responses to the following question on school-leaving:

> *"Do you want to leave school when you are 16, or do you plan to go on to sixth form or college?"*

Because of the longitudinal nature of the BYP, some respondents answered this question on only one occasion, while others answered it more than once, up to a maximum of five times; for respondents giving multiple responses, the response may vary across different waves. We use responses to this question at age 13, for two reasons. Firstly, students in the UK start their GCSE courses in Year 10, when they are aged 14-15; their success in these courses will influence their chances of getting into further education, and it is likely that this may affect their aspirations. Of course, pupils will have a general idea of their academic ability at earlier

[2] In the first wave of BYP (the fourth wave of BHPS) there were 605 households with eligible adolescents, containing around 773 individual adolescents.

ages, but the earlier the question is asked, the lower is the risk that aspirations will be endogenously determined. Secondly, a substantial number of respondents younger than 13 fail to respond to the question on school-leaving. Thus, the response at age 13 represents the best available compromise between sample size on the one hand, and considerations of endogeneity on the other.

A variable measuring respondents' later educational attainment is obtained by examining all available future waves of the BHPS and UKHLS, and recording the highest level of qualification attained. Around 40 per cent of our sample will not have had the chance to finish university degrees, so we construct this variable to distinguish between those who gained no post-16 qualifications and those who gained any qualifications following the end of compulsory schooling. We cannot construct this variable for the very youngest members of our sample, as they have not yet entered post-secondary education by the last time they are interviewed; in addition, while some of those born in 1994 and 1995 have gained their post-secondary qualifications by the time of their last interview, some are still in post-secondary education. For these individuals, we make the assumption that those still in post-compulsory education will go on to obtain post-16 qualifications; 120 cases (around 6% of the sample) are coded in this way. See Appendix A for detailed explanation of the UK educational system.

The distributions of these educational variables were given in Table 1. The percentages of those aspiring to remain in school after age 16, and those actually staying on, are fairly close.

Table 1 Distribution of educational aspiration and attainment

	Aspiration		Attainment	
	Freq	Percent (%)	Freq	Percent (%)
No further education	960	27.04	559	28.23
Further education or above	2,590	72.96	1,421	71.77
Total	3,550	100.00	1,980	100.00

Source: BHPS (1994-2008) & UKHLS (2010)

3.2 Sibling configurations

Variables indicating individuals' number of siblings and birth order were derived from the BHPS relationship files, supplemented by maternal fertility histories collected at Wave 2. The relationship files contain data on all current members of sample households, and their relationships to one another; thus, they provide information on all siblings currently living in the same family. This includes virtually all younger siblings, and older siblings who have not yet left the parental home, but not older siblings who have left home. In order to "find" these older siblings, we use information from the relationship files in all previous waves of the BHPS, plus data from the maternal fertility histories collected in Wave 2, which record all the children which mothers have ever had, including those no longer living at home. [3]

Sibling clusters of size one (that is, only children) were excluded from the analysis. Sibling clusters containing twins were excluded from the sample if the twins were the firstborns in the family, since the experiences of these children may be fundamentally different from those of other firstborns, in that they did not experience an exclusive parental investment period. But if the twins had older sibling(s), they were treated as later-born children with close age spacing, and the whole sibling cluster was retained in the sample.

A small number of sibling clusters where siblings went to live in different households following parental separation were also excluded from the sample, since it was unclear how to differentiate actual birth order from functional birth order. Finally, sibling clusters containing step-siblings were also dropped: unlike full or half-siblings, step-siblings do not share genetic endowments from the same parents, and it may therefore be difficult to disentangle the birth order effects from others; in addition, the family dynamics may differ, for example in respect of the niche partitioning (e.g. Sulloway, 2001).

Birth order is our main interest in this paper, but we also examine the effect of other sibling configurations, including sibship size, age spacing and sex composition. Sibship size, as its name suggests, is defined as the total number of siblings that an individual has. Sex composition is treated as a binary variable describing whether the sibling cluster is a mixed-sex or a single-sex cluster. Age spacing, in this paper, is defined as the average gap between adjacent siblings in the same family (see equation 1) and is measured in months

$$\text{Age spacing} = \frac{\sum_{i=2}^{n}(\text{age}_i - \text{age}_{i-1})}{n-1} \tag{1}$$

In multilevel models, all of these three variables are treated as higher-level variables that vary between families but not between siblings in the same family. They are tabulated in Table B.1 (see the Appendix B).

Respondents' sex and birth cohort are included as lower-level variables, with the birth cohort variable included to control for contextual effects. This is necessary because in our within-

[3] For the Scotland and Wales boost sample the first wave is wave 9 (1999) of the BHPS; and for the Northern Ireland boost sample it is wave 11 (2001).

family design, all firstborns are in an earlier cohort than their later-born siblings; firstborns are thus less likely to have been affected by recent policy changes encouraging pupils to stay on at school (see the Appendix A for detailed explanations).

3.3 Other explanatory variables

In order to account for between-family heterogeneity, we include a set of control variables, many of which have been demonstrated to have important effects on children's educational performance and achievement (e.g. Davis-Kean, 2005; Dearden et al., 1997).

We include mother's birth cohort, maternal education, parental social class, the region where respondents live, and indicators for religion, race and intact family (see Table B.1). These are included in the model as higher-level covariates. In principle, some of these variables may vary between siblings in the same family. For example, if a family moves from one region to another, siblings would grow up in different regions. Parents may gain additional qualifications or move up the social class ladder as their career progresses; thus, later-borns may experience a more favourable familial environment (or, possibly, a less favourable environment) than their older siblings. In fact, we consider these variables to be invariant within families for two main reasons. Firstly, we observe little actual within-family variation for these variables, meaning that there would be not enough statistical power to estimate the effect of variation at within-family level. Second, these within-family variations arguably serve as explanations for why birth order effects exist. As Sulloway (e.g.1999) argued, birth order is a proxy for systematic disparities that are experienced by siblings in the same family. For example, the later-born child has an 'older mother' than his or her elder siblings. Their parents will also be more experienced in parenting, they may be slightly better (but not worse) educated, they may be better off financially (or less commonly, worse off), and they may have less time to spend on effective parenting. Thus, it may be better to think of these within-family variations not as confounders, but as mechanisms that contribute to the birth order effect. Therefore we keep these variables constant for siblings in the same family by using either the baseline (e.g. maternal education) or most consistent value (e.g. region) across different siblings.

The importance of controlling for family background is highlighted by Table 2, which show systematic variations in sibship size and age spacing with socioeconomic status. It shows that the children of low-educated mothers tend to come from larger sibships than children of mothers with higher levels of education; similarly, children whose parents are in the highest social classes are more likely to be from smaller sibships.

Wineberg and McCarthy (1989) found that less educated parents tend to space their children more closely than their higher-educated counterparts. Our data reveals that mothers with the highest educational levels do indeed have rather wider birth intervals; however, these differences are rather small, and there appears to be no systematic relationship between social class and age spacing.

Table 2 Sibship size and age spacing between successive siblings in months, by maternal education and parental social class (row percentages; N=1,503)

		Sibship size			Age spacing	
		1 sibling	2 siblings	3+ siblings	Mean	SD
Maternal education	No qualification (Ref)	30.23	48.84	20.93	39.17	19.46
	Some qualification	47.16	45.41	7.42	38.62	18.08
	Further qualification or higher	51.93	42.77	5.30	39.59	19.52
Parental Social class	Low or unemployed	26.16	56.54	17.30	40.32	17.89
	Manual	38.91	49.79	11.30	40.28	20.04
	Non-Manual	53.74	40.72	5.54	40.35	21.13
	Professional or managerial	54.50	40.24	5.26	37.86	17.87

Source: BHPS (1994-2008) & UKHLS (2010)

4. Methods

Our analyses are mainly based on multilevel modelling (MLM), a statistical method for analyzing data with a hierarchical nesting structure. We choose MLM over other approaches for several reasons. Firstly, the standard multiple regression model depends on the assumption of independence of observations. This assumption is violated in our data since siblings are nested in families: as siblings from the same family share genetic endowments and familial environments, they tend to be more alike than two individuals randomly selected from different families. In this case, traditional regressions will underestimate the standard errors, leading to overstatements of statistical significance (Hox, 2010). Moreover, ignoring the random effect in the logit (logistic) model not only introduces bias in standard errors, but also in the estimates themselves (Rabe-Hesketh & Skrondal, 2008; Rodriguez, 2007). MLM, however, accounts for within-cluster dependency and clustered random effects, leading to more accurate estimates, standard errors and significance tests.

Data with hierarchical structures might alternatively be analyzed using fixed effects (FE) models. These models are able to explore the effects of within-cluster covariates (that is, to explain differences between siblings in the same family as a function of the children's own characteristics). However, MLM offers two main advantages over FE. First, FE models are not able to estimate the effects of any variables which are constant for siblings in the same family. This is problematic, since we are interested in not only birth order effects, but also in the effects of other sibling configurations which do not vary within families, namely sibship size, average age spacing and sex composition within sibling clusters. MLM, by contrast, allows us to investigate within- and between-family variances simultaneously. A second advantage of MLM over FE is that FE models may yield biased estimates when cluster size is small (Rodriguez & Goldman, 1995).

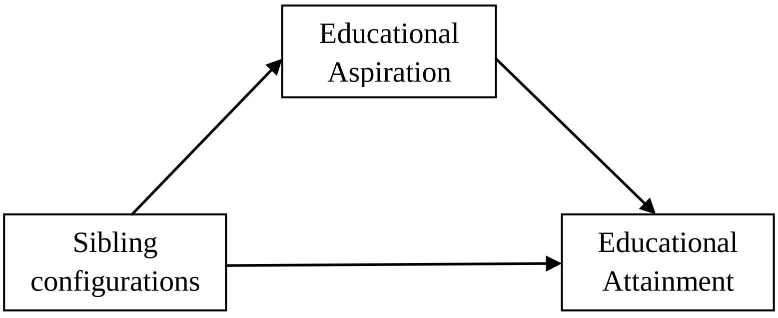
Equation 2 presents a general random intercept logit model.

$$\text{logit}\left[\Pr\left(Y_{ij=1}\right)\right] = \beta_0 + \beta_1 x_{ij} + \beta_2 x_j + \beta_3 x_{ij} x_j + u_j \qquad (2)$$

Sibling clusters are indicated by letter j, and individuals are indicated by i. The dichotomous dependent variable is denoted by Y_{ij} for individual i in sibling cluster j. x_{ij} represents a vector of individual-level explanatory variables, for example birth order and sex; accordingly $\beta_1$represents a vector of coefficients. The vector of cluster-level explanatory variables (e.g. maternal education, parental social class, region etc.) is denoted by x_j. In addition, interaction terms are also tested in the model, with $x_{ij}x_j$ demonstrating the cross-level interaction term.

As Figure 1 illustrates, we hypothesize that sibling configurations (e.g. birth order) not only influence individuals' educational attainment directly, but also have an indirect effect on attainment through aspiration. In order to test these hypotheses, we fit a series of models, starting with the aspiration model to examine how sibling configurations influence individuals' educational aspiration at age of 13. The attainment model is then estimated to test for sibling configuration effects, and how they are affected by accounting for educational aspiration.

Figure 1 Path model diagram



In addition to multilevel models estimated under maximum likelihood (ML), we also estimate multilevel models under the Bayesian framework, using Markov Chain Monte Carlo (MCMC) method. The Bayesian framework differs from the classic frequentist approach in that it does not depend on assumptions of normality and asymptotic convergence (Congdon, 2005; Hamaker & Klugkist, 2011). These assumptions may be violated in discrete response models with problematic sample structure, in this case, a small number of children within sibling clusters (around 2.3 children per family). Thus MCMC estimates provide a useful check of robustness against ML results. MCMC models are fitted in MLwiN 2.28 using default non-informative priors. The burn-in length is set to 500, and iteration to 100,000. We use thinning of 5 to reduce autocorrelation.

In order to examine both the direct and indirect effect of sibling configurations on individual's educational attainment, we also employed path analysis, which is implemented in MPlus 6.0.

5. Results

5.1 Educational Aspiration

Results for the aspiration models are presented in Table 3. All models include sibling configuration variables. In addition to these, Model I controls only for sex and birth cohort, while Model II includes the full set of controls.

In Model I, we observe a significant birth order effect, with firstborn children having significantly higher aspirations than their laterborn siblings. We also observe a negative relationship between sibship size and educational aspiration, with children in the largest sibships having significantly lower levels of aspiration than those in the smallest (two-child) sibships. In this model, the age spacing effect is also statistically significant: children from widely-spaced sibships are less interested in pursuing further education. This runs counter to the theoretical argument that individuals benefit intellectually and educationally from wide age spacing.

In model II, we add other higher level covariates that vary only between families. In this full model, birth order remains a significant predictor of aspirations, with coefficients of 0.41 in both the maximum likelihood and MCMC models. These coefficients translate to a difference in probabilities of around 7% (that is, firstborns are around 7% more likely to aspire to stay on in education than their later-born siblings). For the purposes of comparison, the difference between girls and boys is around 13%. These estimated probabilities, together with standard errors, are plotted in Figure A.2.

The magnitude of the birth order effect alters hardly at all after accounting for family background. By contrast, the coefficients on sibship size and spacing become insignificant after adding new covariates in model II. Because our sample size is relatively small, our estimates may suffer from a lack of statistical power, and we cannot claim definitively that sibship size and spacing do not affect educational aspirations once family background has been controlled for. However, our estimates do suggest that the birth order effect is mainly a within-family phenomenon that is not influenced by between-family factors, while sibship size and spacing are social phenomena that are related to social factors such as education and social class.

Although sex is a strong predictor of individuals' educational aspiration, we find no significant sex composition effects. We also tested for within- and cross-level interaction effects, but find no evidence that, for instance, the birth order effect differs between females and males, or by social class, or by sibship size or age spacing.

For the full model, ML and MCMC methods yield similar estimates. This is partially due to adopting non-informative priors; nevertheless, it provides support for the validation of the ML estimates for our binary model with small cluster size.

Table 3 Educational aspiration models based on ML and MCMC (logit and standard errors)

		Model I		Model II			
		ML		ML		MCMC	
		Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Fixed Part							
cons		1.066*	.193	.389	.340	.414	.346
Lower level variables							
Firstborn (vs. laterborn)		.367*	.096	.407*	.099	.414†	.101
Female (vs. male)		.715*	.090	.724*	.088	.742†	.090
Cohort	1978~1983 (Ref)	--	--	--	--	--	--
	1984~1988	-.017	.142	.081	.147	.075	.152
	1989~1993	-.059	.142	.069	.161	.060	.168
	1994~1998	.086	.155	.247	.187	.244	.194
Higher level variables							
Number of siblings	1 sibling only (Ref)	--	--	--	--	--	--
	2~3 siblings	-.207	.107	-.043	.104	-.046	.105
	4+ siblings	-.680*	.171	-.295	.169	-.304	.175
Gender composition (mixed-sex cluster)		.036	.108	.011	.103	.011	.105
Average age spacing in the household		-.005*	.003	-.004	.002	-.004†	.002
Maternal cohort	1940~1954 (Ref)			--	--	--	--
	1955~1959			-.082	.174	-.078	.177
	1960~1964			-.322	.170	-.320	.174
	1965~1975			-.365	.189	-.365	.191
Maternal education	No qualification (Ref)			--	--	--	--
	Some qualification			.434*	.140	.440†	.146
	Further or high quali			.794*	.140	.809†	.143
Parental social class	Low or unemployed (Ref)			--	--	--	--
	Manual			.303*	.152	.306†	.156
	Non-Manual			.371*	.146	.379†	.150
	Prof. or managerial			.746*	.147	.762†	.151
Parental religion (At least one parent are religious)				.177	.104	.185	.107
Parental race (Both parents are white)				-.571*	.222	-.597†	.230
Intact family				.124	.100	.128	.104
Region	England (Ref)			--	--	--	--
	Wales			.142	.132	.145	.136
	Scotland			-.218	.128	-.221	.132
	Northern Ireland			-.215	.171	-.221	.176
Random Part							
u_j		0.794	0.168	0.471	0.144	0.581	0.165
Sibling clusters (individuals)		1503(3552)		1503(3552)		1503(3552)	

Note: 1) * indicates statistical significance at least at the 5 percent level.

2) Significance inference does not apply for MCMC method under the Bayesian framework. The frequentist inference is based on long-run and repeated sampling frequencies, which, in a sense, is testing the data given certain hypothesis, rather than accessing hypothesis given data at hand (Jackman, 2009). Bayesian approach, however, does not require repeated sampling assumption. It treats parameters under estimation as random variables with certain distribution that is not necessarily normal. The hypothesis testing of these two approaches are fundamentally different. For readers to compare estimates based on these two different methods, a similar criterion is provided: † indicates that 0 is not included within the 95 percent credible interval of the parameters' posterior distributions. This was suggested by Lindley (1965).

5.2 Educational attainment

In this section, we examine the influence of sibling configurations on individuals' educational attainment (in this case, whether they obtain any post-16 qualifications). The models estimated in this section differ slightly from those estimated for aspirations, in that they are based on a smaller sample: only those who reached the age of 16: educational attainment could not be observed or imputed for the youngest subjects, which reduces the last eligible birth cohort to 1995 rather than 1998. Because of this, we use fewer categories when controlling for birth cohort; additionally, variables indicating mother's education, parental social class, intact family and region of residence are measured at age 16 instead of age 13 as in the aspiration model.

Results for three different model specifications are presented in Table 4. All models contain the same set of controls as Model II in Table 3, subject to the differences just outlined. Model III is a standard logit model with robust standard errors. Model IV (a) and (b) are multilevel and MCMC models respectively, with the same set of covariates as Model III. Model V (a) and (b) are the same as Model IV, but with the addition of educational aspiration measured at age 13 as a control.

Comparing Models III and IV, we observe that the single-level logit model, as expected, underestimates standard errors even after adjusting for the clustering in the data. Further, the multilevel estimates are in general larger in magnitude than the ordinary logit estimates. According to Rodriguez (2007), this is usually the case, since neglecting the random effect will cause downward bias of the estimates. But noticeably, the differences between MLM and ordinary logit estimates, at least in this study, are not extreme: both models suggest that firstborns are more likely to achieve post-16 qualifications than their later-born siblings, and that larger age gaps between siblings are associated with higher attainment. Thus, after carefully accounting for between-family covariates, the ordinary logit model may yield reasonably valid results.

Table 4 Educational attainment models based on ML and MCMC (logit and standard errors)

		Model III (Single logit)		Model IV (Multilevel modelling)				Model V (Multilevel modelling)			
		ML		(a) ML		(b) MCMC		(a) ML		(b) MCMC	
		Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Fixed Part											
cons		-.269	.368	-.272	.415	-.329	.426	-.542	.420	-.549	.437
Lower level variables											
Firstborn (vs. laterborn)		.811*	.126	.886*	.140	.930†	.143	.847*	.140	.896†	.145
Female (vs. male)		.297*	.105	.331*	.114	.350†	.118	.271*	.115	.289†	.119
Further education at age 13		--	--	--	--	--	--	.548*	.127	.569†	.133
	1978~1983 (Ref)	--	--	--	--	--	--	--	--	--	--
Cohort	1984~1988	.216	.159	.244	.167	.258	.172	.232	.168	.252	.174
	1989~1995	.106	.185	.140	.193	.154	.200	.131	.193	.152	.201
Higher level variables											
Number of	1 sibling only (Ref)	--	--	--	--	--	--	--	--	--	--
siblings	2~3 siblings	-.199	.128	-.214	.137	-.221	.144	-.195	.137	-.203	.143
	4+ siblings	-.337	.200	-.331	.219	-.327	.231	-.300	.219	-.307	.231
Gender composition (mixed-sex cluster)		.031	.124	.039	.134	.047	.142	.026	.135	.031	.142
Average age spacing in the household		.008*	.003	.008*	.004	.008†	.004	.009*	.004	.009†	.004
Random Part											
u_j		--	--	.386	.192	.587	.230	.360	.191	.591	.218
No. of sibling clusters		864		864		864		864		864	
No. of individuals		1982		1982		1982		1982		1982	

Notes: 1) * indicates statistical significance at least at the 5 percent level.

2) † indicates that 0 is not included within the 95 percent credible interval of the parameters' posterior distributions.

3) A full set of covariates was included in the data analysis, but some variables are omitted for display purpose (see Table B.2 for full models).

4) In contrast to fixed effects (FE), MLM requires further assumption that the cluster effect (u_j) is uncorrelated with the predictors (x_j). If this assumption is violated, the MLM estimates are biased. We test this assumption by using Hausman test (Hausman, 1978). The results indicate the assumption is valid since the MLM yeild estimates that are consistent with the FE. (See Table B.3).

5) The average age spacing in our sample is around 38 months (about 3 years) which may be slightly higher than one might expect. We check the robustness of our models by excluding the outliers in this variable. After excluding sibling clusters with age spacing larger than 8 years (16 observations excluded), the age spacing effect amplifies by 33% in magnitude. But in general, our estimates on other variables of interest remain substantively unchanged.

Turning now to the differences between Models IV and V, we observe how the estimates change with the inclusion of educational aspirations. In the aspiration model, we showed that firstborns have a stronger intention of pursuing further education, and we would expect this to affect their educational attainment (Jocob & Wilder, 2010; Reynolds & Burge, 2008). The question we may ask is whether the birth order effect is still present after accounting for this fact; in other words, whether birth order effects on educational attainment are fully mediated through aspiration.

As shown in Table 4, the birth order effect shrinks marginally after controlling for aspiration, but still remains significant. Predicted probabilities are shown in Figure B.2. On average, the probability of gaining FE qualifications is around 16% higher for firstborns than for their later-born siblings; this is considerably higher than the difference between the sexes, which is only around 4%. In this sense, birth order is a much stronger predictor than sex for further education attainment. Recall that the sex difference is much bigger than birth order in the aspiration model.

It is also interesting, in Table 4, to compare the maximum likelihood (ML) with the MCMC estimates. In both Models IV and V, the two sets of estimates are quite close. However, some differences are noticeable. Firstly, the MCMC estimates of the lower-level variables are larger than the ML estimates – for example, the birth order effect is around 5% larger in the MCMC than the ML estimates. Moreover, the ML approach seems to underestimate the random-intercept variance. Theoretically, the MCMC estimates are thought to be more reliable for models with binary response variables and problematic data structure (Congdon, 2005; Hamaker & Klugkist, 2011). However, these modest disparities would not substantially influence our inferences on sibling configuration effects.

The estimates of the aspiration and attainment models imply that besides an indirect effect mediated by aspiration, birth order has a strong direct effect on individuals' further education attainment. These effects may be tested simultaneously by using a multilevel path model, which is fitted in Mplus 6.0. The path diagram and results are presented in Figure 2 and Table 5. In this model, the estimates of direct birth order effect (γ) and aspiration effect (β) are identical with the full attainment model (Model V). The birth order effect on aspiration (α) is slightly different from the full aspiration model (Model II) estimate. This is because the path model is fitted using the reduced sample (same as the attainment model); while the sample size for the aspiration model is larger since the further education attainment is not required in this model. As the results indicate, the indirect effect of birth order on educational attainment through aspiration is statistically significant. Further, the direct birth order effect is much stronger than the indirect effect which comes via aspiration.

Figure 2 Path model diagram

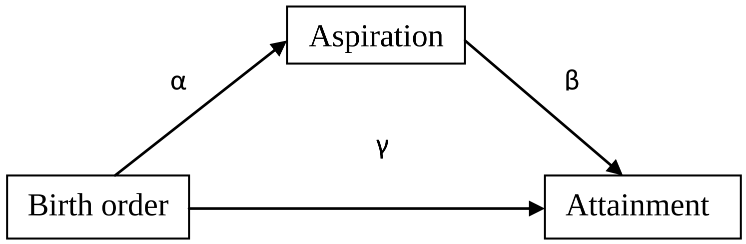


Table 5 Direct and indirect parameter estimations

Parameters	Coef.	SE	P-value
α	.475*	.141	.001
β	.548*	.127	.000
γ (direct effect)	.847*	.140	.000
α*β (indirect effect)	.260*	.098	.007

Note: 1) * indicates statistical significance at least at the 5 percent level
2) Standard error and p-value for the indirect effect was calculated based on the Sobel test.

As discussed in previous section, we find no evidence that age spacing is related to educational aspirations. But in the attainment model, we observe a significantly positive age spacing effect: the wider the age gap is, the more likely that individual attains further education. This suggests that age spacing influences educational attainment only directly; there is no indirect effect through aspiration.

We also examined intra-and across-level interaction effects. Similarly, no evidence is found that birth order effects differ for individual with different sibship size, age gap, parental social class and so forth. But we observe that the birth order effect is slightly stronger in single sex sibling clusters. The probability of attending further education (FE) for firstborns from single-sex sibling clusters is around 16% higher than their later-born siblings; by contrast the birth order difference is around 13% for those from mixed-sex sibling clusters. This interaction effect, however, is only significant at the 10 per cent level.

6. Conclusion

This paper has added to existing literature on sibling configurations in two ways. The first is methodological. Historically, research in this area has relied on between-family designs. These may be criticised on the grounds that they do not control adequately for the relationship between family background and sibling configuration; a number of recent studies (e.g. Wichman, et al., 2006) suggest that the birth order pattern that emerges in the between-family design would disappear under a within-family approach. However, the “pure” within-family approach also has its disadvantages, notably that it cannot estimate the effects of factors which are constant within a family. In this paper, we have used multilevel models, which avoid both of these methodological problems. Using both standard maximum likelihood and robust MCMC models, we provide strong empirical support for birth order effects on education, and argue that these cannot be explained away as a ‘methodological illusion’. We also find that although single-level between-family designs are likely to produce slightly biased estimates, the degree of bias may in fact be small.

The second contribution made by this paper is in introducing educational aspirations into the model, by assessing the role of family configurations on aspirations, and by assessing the role of aspirations as a mediator in the relationship between birth order and attainment. In common with previous empirical studies (e.g. Behrman & Taubman, 1986; Black, et al., 2005; de Haan, 2010), we find that birth order has a direct effect on individual’s educational attainment, specifically that firstborns tend to achieve a higher educational level than their later-born siblings. We find that part of this is an indirect effect mediated by the effects of birth order on aspirations; in other words, the advantage of firstborns in educational outcomes may be partially explained by the fact that firstborns tend to have higher aspirations which push them toward higher educational levels.

This study is not without its limitations. As previously mentioned, the sample is young, with around 40 per cent of sample members still in higher education. Thus we distinguish only between individuals who gained post-16 qualifications and those who did not. As the sample in question matures, we will be able to use the same methodology to assess the effect of family configurations on other margins of educational attainment, most particularly, qualifications at age 18, and at higher education.

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Appendix A: A note on the UK Education system

Our sample of eligible respondents was born between 1978 and 1998. The oldest members of the sample faced the decision about whether to progress to post-16 education in the mid-1990s, while the youngest members faced the same decision two decades later. Those two decades have seen substantial changes in educational policies in the UK, and may have given rise to a cohort effect among our respondents.

The minimum school leaving age was 16 years until 2013[4]. Students then faced the choice of leaving education, or proceeding to post-secondary education. Further education (FE) is typically, though by no means exclusively, delivered between the ages of 16 and 18, and includes A-levels, Scottish Highers, and vocational qualifications including national diplomas and certificates. Higher Education (HE) is typically delivered to those aged 18 and over, and includes Certificates and Diplomas of higher education, foundation degrees, higher national certificates (HNC), higher national diplomas (HND) and degrees[5]. The education system in the UK is presented in Table A.1.

Table A.1 Educational system in the UK (2013)

Educational level	Key stage	Ages	School year	Qualifications
Pre-school	0	3-5	0	
Compulsory education	1	5-7	1-2	
	2	7-11	3-6	
	3	11-14	7-9	
	4	14-16	10-11	GCSEs
Further education	5	16-18	12-13	A-levels, AS-levels, NVQs, National diplomas
Higher education	--	18+	14+	HNC, HND, degree and above

Source: https://www.gov.uk/national-curriculum/overview
Note: The education system is slightly different in Northern Ireland and Scotland, compared with England and Wales, but these differences are not of substantial influence for the purposes of this study.

In recent decades, there have been major policy attempts to promote participation in post-compulsory education in the UK. The first was a reform of the vocational qualification system, designed to revitalise vocational training and enhance its labour market value and attractiveness. General National Vocational Qualifications (GNVQs), a scheme of vocational

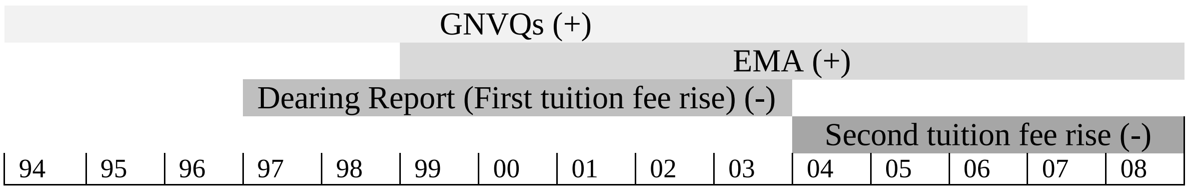
[4] The 16 years old as school leaving age was enforced since 1973. The school leaving age was increased up to 17 in 2013, and is expected to be raised to 18 years old from 2015 onwards.
[5] Source: Quality Assurance Agency for Higher Education (QAA),

qualifications designed to be taught full-time alongside GCSEs and A levels, were introduced in 1993[6]. Since the BHPS youth panel was launched in 1994, this change affected all respondents equally. The second policy initiative was the introduction of the Education Maintenance Allowance (EMA) in 1999. This was a means-tested allowance, designed to encourage young people between 16 and 19 to stay in full-time education by helping them meet additional associated costs. Individuals born in 1983 and afterwards stood to benefit from this allowance; those born earlier did not. The EMA scheme in England was continued until 2010; its discontinuation should not influence our sample members.

A third set of reforms relates to the funding of higher education. Historically, university education in the UK was provided free of charge, with generous maintenance grants and social benefits to cover students' living costs. With the expansion of the HE sector in the 1980s, successive governments sought to contain the public costs. The Dearing Report in 1997 recommended the introduction of a student contribution to tuition fees; students were charged an up-front fee of up to £1,000 annually, with reductions for those from lower-income families. Grants for living expenses were gradually reduced, and were phased out completely in 1999, replaced by a system of loans. In 2004, tuition fees were increased to £3,000, and in 2012, to a maximum of £9000.

These reforms to the HE sector do not directly affect the decision of students to stay on at school after the age of 16. However, if we assume that one purpose of attending further education is to progress to higher education, it is possible that these policy changes might suppress teenagers' aspirations to progress to FE, and their likelihood of actually progressing through this sector.

Figure A.1 Main educational policy changes in the UK from 1994 to 2008



The policy changes discussed, their hypothesised direction of influence on FE enrolment, and the years during which they operated, are shown in Figure A.1. The extent to which

[6] A one-year pilot was introduced in 1992. In 2007, GNVQs were abolished and replaced by vocational GCSEs and A levels.

enrolment has been influenced by the reforms is unclear; however, the past two decades have witnessed a continuous increase in FE participation rates (Clark, 2006), and it is clear that we do need to control for individuals' year of birth in our analyses.

Appendix B: Tables and figures

Table B.1 Descriptive statistics for sibling configuration and other control variables

		Aspiration Model		Attainment Model	
		Mean	SE	Mean	SE
Lower-level variables					
Firstborn (vs. laterborn)		.35	.48	.35	.48
Female (vs. male)		.49	.50	.49	.50
Cohort	1978-1983	.15	.36	.22	.42
	1984-1988	.28	.45	.38	.48
	1989-1993(1)	.34	.47	.40	.49
	1994-1998	.23	.42		
		N = 3,552		N = 1,980	
Higher-level variables					
Number of siblings	1 sibling only (Ref)	.47	.50	.45	.50
	2-3 siblings	.44	.50	.46	.50
	4+ siblings	.08	.27	.09	.29
Gender composition (single-sex vs. mixed-sex cluster)		.68	.47	.67	.47
Average age spacing in the household		39.23	19.07	37.99	17.88
Maternal cohort	1940~1954 (Ref)	.13	.33	.19	.39
	1955~1959	.21	.41	.27	.44
	1960~1964	.31	.46	.33	.47
	1965~1975	.35	.48	.21	.41
Maternal education	No qualification (Ref)	.14	.35	.13	.34
	Some qualification	.30	.46	.28	.45
	Further qualification or higher	.55	.50	.59	.49
Parental social class	Low or unemployed (Ref)	.16	.36	.14	.34
	Manual	.16	.37	.16	.36
	Non-Manual	.24	.43	.23	.42
	Professional or managerial	.44	.50	.47	.50
Parental religion (At least one parent are religious)		.70	.46	.71	.46
Parental race (Both parents are white)		.95	.21	.94	.23
Intact family		.57	.50	.57	.50
Region	England	.57	.50	.63	.48
	Wales	.17	.37	.16	.37
	Scotland	.16	.37	.16	.37
	Northern Ireland	.10	.30	.05	.22
		N = 3,552		N = 1,980	

Source: BHPS (1994-2008) & UKHLS (2010)

Note: As described above, the youngest cohort is missing from the attainment sample; in this sample, we distinguish only three cohorts: 1978-83, 1984-88, and 1989 -95.

Table B.2 Multilevel regression of educational attainment using sibling data based on ML (logit and standard errors)

		Model III		Model IV		Model V	
		Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Fixed Part							
cons		-.269	.406	-.272	.415	-.542	.420
Lower level variables							
Firstborn (vs. laterborn)		.811*	.126	.886*	.140	.847*	.140
Female (vs. male)		.297*	.105	.331*	.114	.271*	.115
Further education aspiration at age 13		--	--	--	--	.548*	.127
Cohort	1978~1983 (Ref)	--	--	--	--	--	--
	1984~1988	.216	.160	.244	.167	.232	.168
	1989~1995	.106	.185	.140	.193	.131	.193
Higher level variables							
Number of siblings	1 sibling only (Ref)	--	--	--	--	--	--
	2~3 siblings	-.200	.128	-.213	.137	-.195	.137
	4+ siblings	-.337	.200	-.331	.219	-.300	.219
Gender composition (mixed-sex cluster)		.031	.124	.039	.135	.026	.135
Average age spacing in the household		.008*	.003	.008*	.004	.009*	.004
Maternal cohort	1940~1954 (Ref)	--	--	--	--	--	--
	1955~1959	-.302	.197	-.337	.195	-.334	.195
	1960~1964	-.373*	.195	-.423*	.198	-.398*	.198
	1965~1975	-.728*	.231	-.813*	.235	-.804*	.234
Maternal education	No qualification (Ref)	--	--	--	--	--	--
	Some qualification	.433*	.178	.485*	.194	.413*	.194
	Further or high quali	.503*	.162	.555*	.186	.455*	.187
Parental social class	Low or unemployed (Ref)	--	--	--	--	--	--
	Manual	.079	.188	.061	.205	.049	.205
	Non-Manual	.227	.183	.222	.201	.188	.202
	Prof. or managerial	.567*	.179	.578*	.196	.502*	.196
Parental religion (At least one parent are religious)		.096	.126	.104	.135	.080	.135
Parental race (Both parents are white)		.050	.228	.057	.250	.081	.250
Intact family		.190	.122	.201	.129	.201	.129
Region	England (Ref)	--	--	--	--	--	--
	Wales	-.071	.160	-.090	.172	-.108	.171
	Scotland	.006	.153	-.004	.172	.029	.172
	Northern Ireland	-.615*	.237	-.687*	.284	-.632*	.283
Random Part							
u_j		--	--	.386	.192	.360	.191
No. of sibling clusters		864		864		864	
No. of individuals		1982		1982		1982	

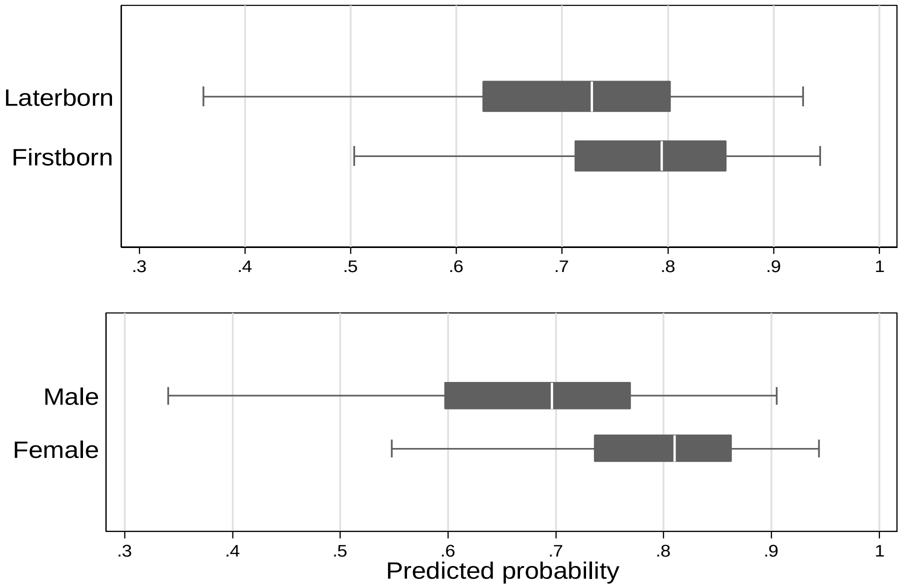
Note: * indicates statistical significance at least at the 5 percent level

Table B.3 Fixed and random effects model comparison

		Coefficients			
		Fixed	Random	Diff.	S.E.
Firstborn (vs. laterborn)		1.095	.886	.209	.093
Female (vs. male)		.400	.331	.069	.103
Cohort	1978~1983 (Ref)	--	--	--	--
	1984~1988	.549	.244	.304	.181
	1989~1995	.713	.140	.572	.281

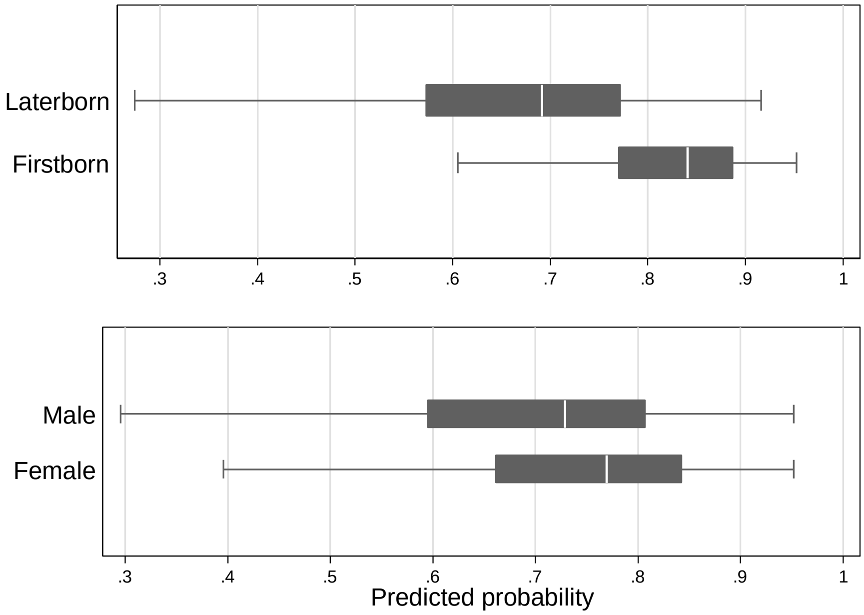
Hausman test: chi2(4)= 5.78, p value=.217

Figure B.1 Predicted probability comparisons of individual's tertiary educational aspiration



Note: Except for the variable of interest (birth order or sex), other variables were set to their means.

Figure B.2 Predicted probability comparisons of individuals' attainment of FE qualifications



Note: Except for the variable of interest (birth order or sex), other variables were set to their means.