Sibling Gender Composition and Participation in STEM Education

Anne Ardila Brenøe*
University of Copenhagen and IZA

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Abstract

This paper studies the causal impact of sibling gender composition on participation in Science, Technology, Engineering, and Mathematics (STEM) education. I focus on a sample of first-born children who all have a younger biological sibling, using rich administrative data on the total Danish population. The randomness of the second-born siblings' gender allows me to estimate the causal effect of having an opposite sex sibling relative to a same sex sibling. The results are robust to family size and show that having a second-born opposite sex sibling makes first-born men *more* and women *less* likely to enroll in a STEM program. Although sibling gender composition has no impact on men's probability of actually completing a STEM degree, it has a powerful effect on women's success within these fields: women with a younger brother are eleven percent less likely to complete any field-specific STEM education relative to women with a sister. I provide evidence that parents of mixed sex children gender-specialize their parenting more than parents of same sex children. These findings indicate that the family environment plays in important role for shaping interests in STEM fields.

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Keywords: Sibling gender, gender-stereotype, STEM, education, field of study.

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*University of Copenhagen, Department of Economics, Øster Farimagsgade 5, Building 26, 1353 Copenhagen K, Denmark. aab@econ.ku.dk. I thank Marianne Bitler, David Card, Ilka Gerhardts, Jennifer Graves, Mette Gørtz, Shelly Lundberg, Heather Royer, Jenna Stearns, Melanie Wasserman, Ulf Zölitz, and seminar participants at the University of Copenhagen (Department of Economics and Department of Sociology), University of California-Santa Barbara, University of California-Berkeley, University of California-Davis, the IZA Summer School in Labor Economics 2017, the Workshop: Education, Skills, and Labor Market Outcomes 2017, the Copenhagen Education Network Workshop 2017, the International Workshop on Applied Economics of Education 2017, Lund University, the 2^{nd} IZA Workshop: Economics of Education, Copenhagen Business School, and Aarhus University for helpful discussions and comments.

1 Introduction

Although women today, on average, attain more education than men across most OECD countries, large gender differences persist in the choice of field of study (OECD, 2016). Only 28 percent of students enrolled in tertiary education within Science, Technology, Engineering, and Mathematics (STEM) are female, while women represent 54 percent of all students. Meanwhile, the returns to field of study vary as much as the returns to level of education, with the greatest returns to STEM fields (Altonji et al., 2015). The gender segregation in field of study persists into occupational choice in the labor market and thereby contributes to the gender wage gap (Blau and Kahn, 2016). At the same time, the STEM workforce is the main contributor to technological innovations, representing the main source of long-run economic growth.[1] Yet, many countries face a shortage of STEM graduates. Given the larger returns to investing in STEM education for both the individual and society, we need to better understand how the social environment interacts with the decision to participate within STEM fields —and in particular women's decision given their current underrepresentation.

Why are so few women in STEM fields compared to men? While boys and girls enter school with same levels of math ability, girls lose interest in math and science throughout elementary school with the consequence that boys have a math test score advantage by middle school (Kahn and Ginther, 2017). Several studies document that different aspects of the social environment during childhood affect gender differences in math test scores. Fewer studies, however, trace effects into the actual choice of studying and working within STEM fields. This is, in part, due to limited data availability, as one needs to link childhood exposure to later educational and, preferably, adult outcomes.

In this paper, I focus on one possible causal factor critical for the development of girls and boys' interests in STEM fields during childhood: sibling gender composition. I use high-quality administrative data for the total population in Denmark from 1980 through 2015 to provide causal estimates of the impact of sibling gender composition on participation in STEM education. In particular, I exploit the random assignment of the second-born child's gender, conditional on the sex of the first-born child and conditional on having a second child. The crux of my identification strategy is to compare STEM participation for first-born children with a second-born opposite sex sibling to those with a same sex sibling. I show that family size is not a confounding factor for the effect of sibling gender composition, although sibling gender composition affects family size as shown in previous studies (e.g. Angrist and Evans (1998)). This empirical approach stands in contrast to previous studies on sibling gender composition, as they generally include all siblings both in the measure of sibling gender composition and in

[1] See, for instance, Atkinson and Mayo (2010); Peri et al. (2015) and references therein.

the estimation sample.[2] Considering the effects of older siblings' gender on younger siblings' outcomes is challenging due to selection bias. Selection bias arises, for instance, if parents decide to have a second child depending on their first child's gender. This, in turn, leads to biased estimates if parents with different gender preferences raise their children differently.

This paper makes three important contributions to the existing literature. First, I study the effect of sibling gender composition on educational STEM choice from first place of enrollment after compulsory schooling (grade 9) through highest completed education by age 30; this is to observe the emergence and persistence of the effect and is only possible due to the unique dataset. Second, I use a new strategy to estimate the causal effect of sibling gender compared to previous studies, which reduces concerns about selection bias. Third, to the best of my knowledge, I am the first to conduct a large quantitative analysis of how sibling gender composition affects child-parent interactions, thereby providing a detailed picture of an important channel through which the effects on STEM participation might operate.

My results suggest that having an opposite sex sibling increases the probability of choosing a gender-stereotypical education. Although sibling gender has only a limited effect on men, it has a significant impact on women's participation in STEM education. Having a second-born brother decreases first-born women's likelihood of ever enrolling in and completing any field-specific STEM education by respectively 5.5 and 10.5 percent. This reduced probability of choosing a program with STEM focus is already present at the first place of enrollment after compulsory schooling and persists into STEM college completion and occupational choice through age 40. Thus, women with a younger brother are more likely to opt out of STEM already at the time of high school application with important consequences for their further educational specialization, field of occupation, and labor market earnings. Meanwhile, men with a younger sister relative to men with a brother are only more likely to enroll in a STEM program, but not consistently more likely to ever complete a field-specific STEM degree or to work within a STEM occupation.

Why does sibling gender alter women and men's likelihood of choosing STEM fields? The impact on field choice could be due to changes in aspects like preferences, interests,

[2] E.g. Amin (2009); Anelli and Peri (2014); Bauer and Gang (2001); Butcher and Case (1994); Conley (2000); Cools and Patacchini (2017); Cyron et al. (2017); Hauser and Kuo (1998); Kaestner (1997); Oguzoglu and Ozbeklik (2016); Rao and Chatterjee (2017). The only exceptions from such strategy are Cronqvist et al. (2015) and Peter et al. (2015), investigating the effect of a co-twin's gender on financial risk taking, attainment, and earnings. Moreover, Gielen et al. (2016) employs a difference-in-differences strategy to estimate the effect of having a male twin on earnings; yet, their interest is whether exposure to prenatal testosterone (rather than sibling gender composition per se) has an effect on earnings. Cools and Patacchini (2017) and Rao and Chatterjee (2017) both provide a robustness check of their estimates on wages where they only consider the sex of a next younger sibling, similar in spirit to my strategy.

identity, and ability. However, I rule out the latter, ability, as sibling gender composition does not affect school performance or attainment. Sibling gender could affect identity, and thereby preferences and interests, through child-parent and/or child-sibling interactions. I provide compelling evidence that changes in child-parent interactions —and, in particular, increased gender-specialized parenting in families with mixed sex children —play an important role for the changes in STEM participation. Drawing on time use data, I show that parents of mixed sex children invest more gender-specifically in their first-born child, especially in families with first-born daughters, than parents of same sex children. This translates into a substantially worse relationship between fathers and their first-born daughters when the second-born child is male relative to female. Moreover, I find the effects on STEM choice to be strongest for individuals with a more "gender-stereotypical" same sex parent.

These findings are consistent with the argument, similar to the one put forward in the same sex education literature (Booth et al., 2013; Schneeweis and Zweimüller, 2012), that having an opposite sex sibling increases the child's exposure to gender-stereotypical behavior and thereby increases his or her inclination to acquire more traditional gender norms. In support of this argument, Cools and Patacchini (2017) show that women with at least one brother hold more traditional gender attitudes than those without any brother. I further show that boys with a younger sister are more exposed to gender-stereotypical behavior within the family than boys with a younger brother. Consequently, my findings emphasize that if policy makers want to increase the number of people —and particularly women —within STEM fields, they need to focus on childhood exposure to gender-stereotypes in the social environment, including the family.

My focus on the social environment is consonant with recent studies that trace gender gaps in educational outcomes to factors such as teacher stereotypes, the gender of school peers and teachers, and parental and sibling role models.[3] Previous studies examining sibling gender composition and later life outcomes have predominantly been concerned with educational attainment, while a couple of more recent papers focus on wages.[4] Overall, the literature on sibling gender composition and educational attainment provides inconsistent findings, though with an overweight of studies reaching statistically insignificant associations.[5] In contrast, studies on wages reach a more consistent finding that male wages are positively and female wages are negatively associated with having a brother.[6] Only two existing studies investigate

[3]See e.g. Anelli and Peri (2014, 2016); Bottia et al. (2015); Brenøe and Lundberg (2017); Brenøe and Zölitz (2017); Carrell et al. (2010); Cheng et al. (2017); Favara (2012); Zölitz and Feld (2017); Humlum et al. (2017); Joensen and Nielsen (2017); Lavy and Sand (2015); Oguzoglu and Ozbeklik (2016).

[4]See the references in Footnote 2.

[5]A general problem, though, is small sample sizes, often resulting in quite imprecise estimates.

[6]Although Cools and Patacchini (2017) do not find that the association for men is statistically significant,

associations between sibling gender composition and field of college enrollment (Anelli and Peri, 2016; Oguzoglu and Ozbeklik, 2016). These studies, however, face challenges in terms of selection bias and data availability. At the same time, no previous study has examined how the effects develop from childhood through adulthood or provided a comprehensive analysis of child-parent interactions as an important mechanism.

In contrast to my findings, Anelli and Peri (2014) do not find a relationship between sibling gender and women's probability of enrolling in a high earnings (male-dominated) college major. Meanwhile, they do find that men of any parity with any sister are more likely to enroll in such major compared to men without any sister. Nevertheless, they do not examine whether these effects persist into actual degree completion or labor market outcomes, which seems important as Anelli and Peri (2016), using the same dataset, find that gender peer effects on college major choice for men are only short lived.[7] Oguzoglu and Ozbeklik (2016) find that among women with a father employed in a STEM occupation, those with at least one brother are less likely to have declare a STEM major in college relative to those without any brother.[8] The authors suggest that this patterns is due to differences in fathers' transmission of occupation-specific tastes and preferences, although they are unable to test for such mechanisms. While Anelli and Peri (2016) and Oguzoglu and Ozbeklik (2016) make an important contribution by studying how field of college major correlates with sibling gender composition, I add to this literature by examining, in a more complete way, how sibling gender composition affects participation in STEM from puberty well into adulthood and how it affects child-parent interactions.[9]

2 Empirical Strategy

The aim is to estimate the causal effect of sibling gender composition on STEM participation. Simply comparing children from families with different gender compositions would, however, not provide valid estimates of the causal effects of sibling gender composition due to selection. The final gender composition in a family is endogenous, as parents decide whether or not to have more children after each child birth and thereby

they cannot rule out an estimate of similar magnitude as other papers finding a statistically significant effect (Gielen et al., 2016; Peter et al., 2015; Rao and Chatterjee, 2017). Similarly, Rao and Chatterjee (2017) do not find a statistically significant effect on female wages, but given the sign and imprecision of most estimates, they cannot rule out negative effects of having any brother.

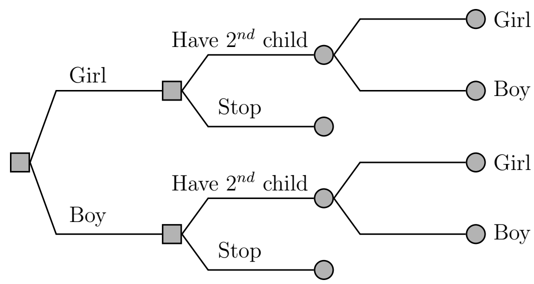
[7]Moreover, the authors face an important limitation for the study of sibling gender composition, as the dataset only includes siblings who complete an academic high school degree in one city in Italy.

[8]These findings, however, rest on only 115 women having a STEM father. Despite being statistically insignificant, their estimates suggest that having any brother is negatively associated with declaring a STEM major among all women.

[9]Finally, I address potential selection problems and can thereby say more about causality.

when knowing their current children's gender composition.[10] Figure 1 illustrates parents' fertility decision.[11] If parents' decision to have a second child depends on the first child's gender and if such gender preferences also affects how parents raise their children, it is not possible to estimate the causal effect of "current" children's gender on "future" children's outcomes because not all "future" children are born.[12]

Figure 1
Example: Parents' Fertility Decision



Note: Parents either get a first-born girl or boy. Given the gender of the first child, they decide to have a second child or to stop having children. Given the decision to have a second child and given the gender of the first child, the gender of the second child is random.

To reach the goal of estimating the causal effect of sibling gender composition, I exploit the random assignment of the second-born child's gender. Because parents do not know the gender of a subsequent child when they make the decision to progress to the next parity, we *can* causally estimate the effect of "future" children's gender on "current" children's outcomes. Thus, I leverage the random assignment of the second child's gender conditional on the gender of the first child and conditional on the parents having a second child. In other words, I leverage two sets of comparisons: 1) I compare first-born women who have a second-born brother to first-born women who have a second-born sister and 2) vice versa for men. I always estimate the model separately for men and women, as they might come from different types of families and because the outcomes of men and women differ substantially.

[10]Parents in developed countries are, for instance, more likely to have a third child if their first two children are of same compared to mixed gender (Angrist and Evans, 1998; Angrist et al., 2010; Black et al., 2005).

[11]An extreme reason for not having a second child if the first child is not of the preferred gender could be divorce. Some U.S. studies find an increased divorce risk when having a first-born girl (Bedard and Deschenes, 2005; Dahl and Moretti, 2008), while Kabtek and Ribar (2017) do not find support for this for the Netherlands.

[12]Appendix A.1 shows the selection bias problem more formally and discusses other reasons for selection bias than parental gender preferences.

The empirical specification for the main analysis is:

$$Y_i^{First-Born} = \alpha_0 + \alpha_1 Opposite\ Sex_i^{Second-Born} + X_i'\delta + \nu_i, \quad (1)$$

where $Y_i^{First-Born}$ indicates whether individual i (who is first-born) participates in STEM education and the estimate of interest is α_1, i.e. the effect of having a second-born sibling of the opposite sex. X_i is a vector of fixed effects for birth municipality, year-by-month of birth, spacing in months to the second-born sibling, immigrant status, maternal age at birth, paternal age at birth, maternal level-by-field of education, and paternal level-by-field of education.[13] ν_i is the error term and is clustered at the year-by-month of birth level.[14]

As this strategy only relies on the random assignment of the second child's sex, parents can respond to the gender composition of their first two children in terms of subsequent fertility. Appendix Table A2 shows that, for the main sample of the analysis (described in Section 3), having a second-born sibling of the opposite sex reduces, on average, first-born women and men's family size by 0.07 and 0.08 siblings, respectively. Therefore, family size might mediate some of the effect of having a second-born opposite sex sibling if family size has an independent impact on STEM participation.

Existing studies find that family size does not affect educational attainment in either Israel or Norway, using twins as an instrument for family size (Angrist et al., 2010; Black et al., 2005). In Appendix A.2, I replicate this finding in the Danish context and show that family size only has a borderline significant effect on women's probability of completing a STEM degree, while there is no effect for men or on STEM enrollment. The results in Appendix Table A1 suggest that having one additional sibling reduces women's probability of completing a STEM degree by 1.1 percentage points. Scaling this effect, for women, by the effect of having a second-born brother on family size suggests that family size mediates ($-0.07 \times -1.1 =$) 0.08 percentage points of any potential effect on STEM completion. As the main results suggest that women with a younger brother relative to women with a younger sister are less likely to participate in STEM, the effects of sibling gender composition for women might therefore be conservative. Moreover, I show that sibling gender composition does not affect educational attainment or achievement (Subsection 4.2). Finally, Subsection 6.1 further tests the robustness of the results to family size. Based on these different pieces of evidence, family size does not seem to be an important confounder of the effect of sibling gender, but might, if anything, bias the effect towards zero for women.

[13] If the parent does not have a field-specific education, I use the field of occupation.

[14] However, the level of clustering does not make any difference for the results.

3 Data

3.1 Data and Sample Selection

I use Danish administrative data for the total population from 1980 through 2015. One central feature of this dataset, compared to most previous studies on sibling gender composition, is that I can link all children to their parents and siblings. Thus, I observe parents' complete fertility history and thereby, correctly measure the sibling gender composition. Furthermore, I have information on parents' date of birth; length, type, and field of education; labor market attachment; and occupation.[15] For the children, I observe every time a person enrolls in an education and have detailed information on the characteristics of the program, such as level, type, and field; data on enrollment is available since 1978. The educational registry further reports the highest completed degree at an annual basis. Throughout, I follow the International Standard Classification of Education (ISCED) for the definition of all educational measures. I include observations through age 27 for all enrollment measures and through age 30 for all completion measures to give people time to complete the education in which they enroll. Finally, I also observe the children's annual labor earnings and occupation.

I restrict the sample to cohorts born between 1962 and 1986 to allow for sufficient time to enroll and complete an education. Moreover, I only include first-born children, who are the first child to both the mother and father; I exclude first generation immigrants to eliminate concerns about unobserved siblings in the data and because I might not observe all their educational history; I only consider individuals who have at least one full sibling (same mother and father) born less than four years apart and who survives the first year of life; I exclude families where either the first or second child is a twin; and finally, I exclude those few individual's who die before age 30 or do not live in Denmark at any time between age 26 and 30.[16] I refer to this sample of first-born children as the *main sample*.

Panel A in Table 1 provides descriptive statistics on demographic characteristics of the main sample by sibling gender composition. Overall, first-born men and women come from very similar family backgrounds regardless of sibling gender. One-third of the sample is born in one of the two largest metropolitan areas in Denmark (Greater Copenhagen and Aarhus) and another third is born in Jutland outside the County of Aarhus. Average spacing to the younger sibling is 2.5 years and 1.2 percent are second

[15]The registers started to report occupation in 1991. To characterize parental occupation, I use the mode occupation from 1991–2000.

[16]The last restriction leads to the exclusion of 3,979 individuals due to death by age 30 (of whom 17 percent die before their first birthday) and 8,985 individuals due to emigration. Moreover, I also exclude those very few individuals (569) who do not live in Denmark for more than ten years between age 13 and 30. Sibling gender composition does not affect the attrition due to these restrictions.

Table 1
Descriptive Statistics and Balancing Test by Sibling Gender Composition

	First-Born Women			*First-Born Men*		
Panel A: Average by Gender of the Second-Born Sibling and t-test of Difference						
Second-Born	Sister	Brother	p-value	Sister	Brother	p-value
	(1)	(2)	(3)	(4)	(5)	(6)
Region of Birth (pct.)						
Greater Copenhagen	23.86	23.70	0.46	23.97	23.81	0.44
Rest of Zealand	17.74	17.99	0.18	17.70	17.97	0.15
Funen	8.58	8.67	0.49	8.64	8.56	0.52
Aarhus	12.59	12.43	0.32	12.49	12.46	0.84
Rest of Jutland	36.93	36.90	0.90	36.97	36.96	0.98
Greenland	0.30	0.30	0.88	0.24	0.25	0.54
Spacing (months)	30.43	30.48	0.28	30.48	30.43	0.23
2^{nd} Gen. Immigrant (pct.)	1.17	1.15	0.76	1.15	1.08	0.13
Mother's age (years)	23.30	23.26	0.03	23.32	23.31	0.72
Father's age (years)	26.06	26.02	0.03	26.05	26.03	0.41
Mother's education (years)	11.21	11.20	0.86	11.21	11.23	0.16
Mother's edu unknown (pct.)	2.19	2.15	0.54	1.98	2.03	0.41
Father's education (years)	11.99	11.99	0.89	11.99	12.03	0.02
Father's edu unknown (pct.)	3.32	3.37	0.58	3.20	3.20	0.97
Parental field of education/occupation (pct.)						
Mother in Admin.	31.77	31.89	0.60	31.86	32.01	0.49
Mother in Health	11.97	12.21	0.13	12.00	12.32	0.04
Father in STEM	43.08	42.66	0.08	43.05	42.97	0.73
Observations	80,593	84,140		84,360	88,980	
Panel B: Balancing Test						
Joint F-statistic	0.90			0.95		
Prob > F	0.98			0.83		

Note: Main sample (first-born children born 1962–1986 with a second-born biological sibling born within four years apart). Panel A shows the average of family background characteristics for first-born women with a second-born female [Column (1)] and male sibling [Column (2)] and first-born men with a second-born female [Column (4)] and male sibling [Column (5)]. Columns (3) and (6) report the p-values from t-tests of significance between women and men with siblings of different gender, respectively. The balancing test tests whether the control variables included in X_i in Equation (1) can predict having a younger opposite sex sibling. F-test of joint significance of all control variables.

generation immigrants. Mothers are, on average, 23.3 years at birth and have 11.2 years of education, while fathers are 26.0 years and have 12.0 years of education. A large share of parents are within very gender-typed fields. Thirty-two and 12 percent of mothers are respectively within low- or medium-level administration and health fields, while 43 percent of fathers are within STEM fields.[17]

3.2 Randomization Checks

For the empirical strategy to provide a valid estimate of the causal effect of sibling gender composition on STEM participation, the sex of the second child needs truly to be random. This Subsection provides evidence, supporting the identifying assumption of random assignment. In Panel A in Table 1, Columns (3) and (6) test whether the background characteristics for first-born women and men, respectively, differ by gender of the second-born sibling. Most differences are statistically insignificant at conventional levels and those differences that are statistically significant are small and, to some extent, expected due to the large sample size and the number of t-tests.[18] To account for these small baseline differences, as outlined in Section 2, I flexibly control for parental age and education among a wide range of other fixed effects in the analysis.

Panel B shows statistics from a balancing test, testing whether the demographic characteristics included in X_i in equation (1) can predict having a sibling of the opposite sex. More precisely, it reports the F-test of joint significance of all the covariates in a regression where the outcome is an indicator for having a second-born sibling of the opposite sex. The F-test strongly rejects joint significance for both samples. Thus, this balancing test supports the identifying assumption that the younger sibling's gender is random conditional on the first child's gender.

As I the annual data starts in 1980, I do not observe time-varying parental characteristics before birth for most individuals in the main sample. However, for later cohorts, I can check whether parents with a second-born opposite sex child differ from parents with a second-born same sex child. The graphs in Appendix Figure A6 illus-

[17] I have defined these very gender-typed fields based on having a great majority of graduates/workers of one gender within these fields. Maternal field in administration is defined as having a field-specific education within Education; Arts and Humanities; or Business, Administration, and Law (ISCED fields 2, 3, and 4) or having an occupation as Business and Administration Associate Professional (ISCO-08 sub-major group 33) or Clerical Support Workers (ISCO-08 major group 4) conditional on not having any field-specific education. Maternal field in health is defined as having a field-specific education within Health below Master level (ISCED field 9) or having an occupation as Health Professional or Health Associate Professional (ISCO-08 sub-major groups 22 and 32) conditional on not having any field-specific education. Paternal field in STEM is defined as having a field-specific education within STEM (ISCED fields 5–7) or having an occupation as Science and Engineering Professional; Science and Engineering Associate Professional; Craft and Related Trades Workers; or Laborer in Mining, Construction, Manufacturing, and Transport (ISCO-08 sub-major groups 21, 31, 71–75, and 93) conditional on not having any field-specific education.

[18] Due to assortative mating, the difference for women is statistically significant for both parents' age.

trate the estimates from an event study of the effect of having a second child of the opposite sex on a variety of parental SES characteristics. This is estimated separately by the gender of the first child, although shown in the same graph, from five years before the first child's birth through 14 years after for cohorts born between 1985 and 2002. The gender composition of children does not affect parental cohabitation, marital status, length of education, parental employment, or parental annual labor earnings before or around the birth of their first child.[19] This further supports the randomness of the second child's gender.

3.3 Education and Field of Study

The first nine years of schooling constitute compulsory education in Denmark.[20] In the final year of 9^{th} grade, students decide whether they want to apply for secondary education or enter the labor market.[21] Secondary education (ISCED level 3) consists of two types: academic high school and vocational training. The academic high school is generic (i.e. not field-specific) and prepares students for tertiary education. Overall, it has four tracks (language, math, technical, and commercial), of which I group the math and technical tracks as STEM-preparing. Vocational education is, in contrast, field-specific and prepares students for specific occupations; I group Information and Communication Technologies and Engineering (ISCED fields 61 and 71) as STEM.

Tertiary education (ISCED levels 5–8) consists of three types: vocational, professional, and academic. I refer to the latter two jointly as *college*. Similarly, I group vocational secondary and vocational tertiary educations as *vocational education*.[22] A vocational secondary degree usually only gives direct access to vocational tertiary programs within the same specific field,[23] while an academic high school diploma gives access to all types of tertiary education, An application to tertiary education is an application to a specific program. Most college STEM programs have certain STEM

[19]Note, that the only systematic difference in parental SES characteristics after the first child's birth by sibling gender composition is a positive effect of having mixed sex children on maternal labor earnings between six and nine years by three to five percent after the first child's birth (the measure of earnings does not include parental leave benefit, implying that the effect on total income is smaller than the estimated effect on labor earnings). Thus, the socio-economic conditions experienced during childhood do not, overall, seem to differ by sibling gender composition besides the increased probability of living in a larger family as shown in Appendix Table A2.

[20]For the cohorts of study, it was common to attend a so-called kindergarten class at age 6 the year before starting first grade, although it was not mandatory.

[21]They can also choose to enroll in an optional 10^{th} grade, which is formally a continuation of primary school. In the analysis, I restrict the attention to enrollment in and completion of programs after primary school, i.e. after grade 9 and 10.

[22]Distinguishing by level gives very similar results.

[23]Students with a vocational secondary degree will often be required to have taken one or two academic high school courses at a basic level, such as Math and English. Many vocational secondary programs do not have a natural continuation at the tertiary level, though.

high school courses as prerequisites, such as advanced Math and intermediate Physics and Chemistry. Therefore, an academic high school STEM diploma gives much easier access to college STEM majors than other secondary school degrees, although it is possible to take complementary courses after high school graduation. Acceptance to college mainly depends on the grade point average (GPA) from high school and most STEM programs admit all eligible applicants (or have very low GPA cutoffs).

As women's underrepresentation in STEM is limited to math-intensive —and, generally, better paid—science fields (Kahn and Ginther, 2017), my preferred definition of STEM college majors exclude Biological and Related Sciences (ISCED field 51, henceforth *Biology*).[24] I follow Kahn and Ginther (2017) by defining hard sciences in college as Physical Sciences, Mathematics, Statistics, Economics, Information and Communication Technologies, and Engineering (ISCED fields 53, 54, 311, 61, 71) and refer to this definition as *STEM excluding Biology*. However, I also show the results when including Biology in the STEM definition and refer to this measure as *STEM including Biology*. The main analysis of STEM education considers field-specific STEM educations in any type and at any level of education after primary school. This is to not potentially confound the results on STEM choice with educational attainment. Thus, the main outcomes of interest indicate whether the individual ever enrolls in and completes a field-specific STEM education preparing for the labor market, including secondary and tertiary vocational STEM programs and college STEM majors. On average, 4.8 (5.9) and 28.7 (29.2) percent of women and men, respectively, complete a field-specific STEM education excluding (including) Biology; these numbers have been relatively stable across cohorts [Appendix Figure A2].

Because the results in Subsection 4.2 demonstrate that sibling gender composition does not affect educational attainment, I complement the main STEM measures with nine additional outcomes. I examine whether the first place of enrollment after primary school has a STEM focus, i.e. whether it is either secondary STEM vocational education or in the STEM-preparing track in the academic high school. In line with this, I consider the probability of ever enrolling in and completing the academic high school STEM track. Finally, I split field-specific STEM educations by type, thereby investigating effects on the probability of studying in and completing a vocational STEM program and a college STEM (both including and excluding Biology) major, separately.[25]

[24] I group Environment (ISCED field 52) together with Biology, as very few study within that field. Appendix Figure A1 illustrates men and women's average earnings percentile by birth cohort at age 35 by type and field of highest completed education as well as the male share in each cell. Of those who have a college Biology major, only 33 percent are male and average male earnings are substantially lower than for other STEM degrees.

[25] Considering whether the highest completed education is within STEM reveals very similar results as for having any field-specific STEM degree (not reported).

4 Results

4.1 STEM Education

Table 2
Field-Specific STEM Enrollment and Completion

	STEM Enrollment		STEM Completion	
	Excl. Biology (1)	Incl. Biology (2)	Excl. Biology (3)	Incl. Biology (4)
Sample of First-Born Women				
Second-Born Brother	-0.48*** (0.14)	-0.51*** (0.15)	-0.53*** (0.10)	-0.58*** (0.11)
Same Sex Baseline	8.7	10.1	5.0	6.2
Percent Effect	-5.5	-5.1	-10.5	-9.3
Observations	164,733			
Sample of First-Born Men				
Second-Born Sister	0.80*** (0.23)	0.77*** (0.23)	0.32 (0.22)	0.33 (0.22)
Same Sex Baseline	40.9	41.5	28.5	29.1
Percent Effect	2.0	1.9	1.1	1.1
Observations	173,340			

All estimates are multiplied by 100 to express effects in percentage points. Standard errors in parentheses, clustered at the year-month of birth level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Main sample (first-born children born 1962–1986 with a second-born biological sibling born within four years apart). Each Panel-Column presents estimates from separate regressions. All models absorb fixed effects for birth municipality, year-month of birth, spacing in months to younger sibling, second generation immigrant status, maternal age at birth, paternal age at birth, maternal level-field of education, paternal level-field of education, and age at last educational observation. *Same Sex Baseline* reports the mean outcome for individuals with a same sex sibling. *Percent Effect* reports the estimated effect of sibling gender relative to the baseline. *Field-specific STEM* education refers to vocational and college programs.

Table 2 shows the main results on sibling gender composition and STEM education by gender.[26] First-born women with a second-born brother are 0.48 (0.53) percentage

[26] Appendix Figure A3 illustrates the raw difference by gender and cohort. Appendix Table A3 shows the results with alternative control versions, illustrating that the estimates are almost identical regardless of the covariates included, supporting the assumption that sibling gender is random.

points less likely to ever enroll in any field-specific STEM program excluding (including) Biology relative to those with a sister. Given a baseline average of 8.7 (10.1) percent for women with a sister, the relative change corresponds to a decrease by 5.5 (5.1) percent. This effect persists into educational attainment, resulting in a decreased probability of ever completing a STEM degree by 10.5 (9.3) percent. The effects are very similar when considering STEM including Biology, though the percent effect is slightly smaller due to a larger baseline. These results consequently demonstrate that sibling gender has a powerful effect on women's likelihood of going into traditionally male-dominated STEM fields.

In contrast, first-born men with a younger sister are more likely than men with a brother to enroll in an education within STEM excluding (including) Biology by 0.80 (0.77) percentage points, representing a relative effect of 2.0 (1.9) percent. The estimated impact is larger in magnitude than for women; however, due to a larger baseline (40.9 percent), the relative effect is only around one-third of the one for women. At the same time, sibling gender has no statistically significant effect on men's probability of completing a STEM education and the magnitude of the effect is small (0.32 percentage points; 1.1 percent).

To elaborate on the main results, Table 3 provides a more nuanced picture on the educational process related to STEM fields from first place of enrollment after grade 9 through age 30. Sibling gender already impacts women's first active educational choice: women with a younger brother are 3.5 percent less likely to enroll in a program with emphasis on STEM subjects as their first place of enrollment after compulsory schooling. As only very few women enroll in secondary vocational STEM programs, this effect is entirely driven by a decreased probability of enrolling in and completing the STEM tracks in the academic high school. After secondary schooling, women with a younger brother are again less likely to choose a STEM education. Women with a brother compared to women with a sister are 9.0 percent less likely to complete a vocational STEM degree and 11.5 (9.5) percent less likely to complete a STEM college major excluding (including) Biology. Consequently, these results show that once women opt *out* of STEM fields—which already happens at the time of high school application—they do not opt *in* again and that women fall out of STEM for each educational transition. These findings stress that women's choice not to study within STEM fields originates to the time before exiting compulsory education but is not only limited to that period.

Table 3

STEM Education from end of Compulsory Schooling through Age 30

	STEM Focus in First	Academic High School STEM Track		Vocational STEM (Secondary and Tertiary levels)		College STEM Major			
	Enrollment	Enrollment	Completion	Enrollment	Completion	Excl. Enrollment	Incl. Enrollment	Excl. Completion	Incl. Completion
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Sample of First-Born Women									
Second-Born Brother	-0.89***	-0.91***	-0.87***	-0.18*	-0.18***	-0.37***	-0.43***	-0.36***	-0.41***
	(0.21)	(0.22)	(0.19)	(0.11)	(0.07)	(0.10)	(0.11)	(0.08)	(0.10)
Same Sex Baseline	25.7	26.7	20.8	4.2	2.0	4.9	6.3	3.1	4.3
Percent Effect	-3.5	-3.4	-4.2	-4.3	-9.0	-7.6	-6.8	-11.5	-9.5
Observations					164,733				
Sample of First-Born Men									
Second-Born Sister	0.40*	0.22	0.12	0.53**	0.26	0.33**	0.30*	0.09	0.09
	(0.24)	(0.23)	(0.19)	(0.22)	(0.20)	(0.15)	(0.15)	(0.13)	(0.14)
Same Sex Baseline	51.5	36.0	25.2	30.4	21.0	12.5	13.2	8.3	8.8
Percent Effect	0.8	0.6	0.5	1.7	1.2	2.6	2.3	1.1	1.0
Observations					173,340				

All estimates are multiplied by 100 to express effects in percentage points. Standard errors in parentheses, clustered at the year-month of birth level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Main sample (first-born children born 1962–1986 with a second-born biological sibling born within four years apart). Each Panel-Column presents estimates from separate regressions. All models absorb fixed effects for birth municipality, year-month of birth, spacing in months to younger sibling, second generation immigrant status, maternal age at birth, paternal age at birth, maternal level-field of education, paternal level-field of education, and age at last educational observation. *Same Sex Baseline* reports the mean outcome for individuals with a same sex sibling. *Percent Effect* reports the estimated effect of sibling gender relative to the baseline. *STEM Focus in First Enrollment* indicates whether the first place of enrollment after compulsory education is within STEM (vocational secondary or academic high school). *Academic High School STEM Track* indicates enrollment in and completion of academic high school from the math or technical tracks. *Vocational STEM* indicates enrollment in or completion of a vocational STEM program either at the secondary or tertiary level. *College STEM Major* indicates enrollment in and completion of a college STEM program.

For men, the story is different. Men with a younger sister are only slightly more likely to enroll in a program with STEM focus as their first place of enrollment (0.8 percent). The percent effect increases, though, when restricting STEM enrollment to vocational programs (1.7 percent) and STEM college majors excluding Biology (2.6 percent). In line with the main results, sibling gender does not have a statistically significant impact on STEM completion for any of these separate types of education. Thus, although sibling gender affects men's likelihood of choosing an education within STEM fields, the effect does not persists into actual degree completion. As the next subsection shows that sibling gender composition does not affect school performance, the results support an interpretation of changed interests in STEM fields, but that sibling gender does not improve men's ability to actually succeed in STEM programs.

The results are, broadly, comparable to other studies on STEM choice both in terms of the magnitude of the effects and finding largest effects for women. For instance, having a one standard deviation larger proportion of female math and science teachers in high school (Bottia et al., 2015) and in introductory courses in the U.S. Air Force Academy (Carrell et al., 2010) increases women's probability of graduating with a STEM college major by almost 10 percent (no effect for men). However, the latter study only finds an effect for women with above median math ability. Similarly, increasing the proportion of female peers in lower secondary education by one standard deviation in Austria increases the probability that girls choose a typical male track by 13 percent (Schneeweis and Zweimüller, 2012). Fischer (2017) further finds that women who are enrolled in a class with a one standard deviation larger share of high ability peers in college introductory Chemistry classes are seven percent less likely to graduate in STEM, while men's STEM persistence is unaffected. Other studies on gender peer composition, in contrast, find that a larger share of female peers increases both men and women's probability of choosing a more gender-stereotypical college major (Brenøe and Zölitz, 2017; Zölitz and Feld, 2017).

4.2 Educational Performance and Attainment

The findings on STEM education could be due to changes in ability and educational attainment. If sibling gender largely impacts ability, an effect on field choice could simply be a rational response even though the interest in STEM fields stays constant. Appendix Table A4 shows that sibling gender composition has no effect on either girls or boys' school performance, a proxy for ability.[27] Moreover, one might worry that

[27] Appendix Table A4 also shows that sibling gender composition does not affect the probability of being observed with any of the GPA measures. Appendix Figure A4 illustrates the distributions of the three GPA measures by gender and sibling gender composition. The differences by sibling gender are extremely small and distributional effects do not seem to be important.

Table 4
Educational Enrollment and Attainment by Age 30

	Post-Compulsory		Vocational		College	
	Enroll-ment (1)	Com-pletion (2)	Enroll-ment (3)	Com-pletion (4)	Enroll-ment (5)	Com-pletion (6)
Sample of First-Born Women						
Second-Born	0.00	-0.09	-0.06	0.04	-0.04	-0.20
Brother	(0.12)	(0.17)	(0.24)	(0.23)	(0.21)	(0.22)
Same Sex Baseline	95.2	85.7	54.3	40.5	45.7	38.5
Percent Effect	0.0	-0.1	-0.1	0.1	-0.1	-0.5
Observations			164,733			
Sample of First-Born Men						
Second-Born	-0.06	-0.20	0.13	-0.06	-0.06	-0.28
Sister	(0.10)	(0.19)	(0.21)	(0.24)	(0.20)	(0.20)
Same Sex Baseline	94.7	82.4	66.2	50.9	34.0	26.8
Percent Effect	-0.1	-0.2	0.2	-0.1	-0.2	-1.0
Observations			173,340			

All estimates are multiplied by 100 to express effects in percentage points. Standard errors in parentheses, clustered at the year-month of birth level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Main sample (first-born children born 1962–1986 with a second-born biological sibling born within four years apart). Each Panel-Column presents estimates from separate regressions. All models absorb fixed effects for birth municipality, year-month of birth, spacing in months to younger sibling, second generation immigrant status, maternal age at birth, paternal age at birth, maternal level-field of education, paternal level-field of education, and age at last educational observation. *Same Sex Baseline* reports the mean outcome for individuals with a same sex sibling. *Percent Effect* reports the estimated effect of sibling gender relative to the baseline. *Post-Compulsory* indicates enrollment in and completion of any type of education after primary school. *Vocational* refers to enrollment in and completion of vocational secondary and tertiary programs. *College* refers to enrollment in and completion of college programs.

sibling gender could affect the probability of any enrollment and thereby enrollment in any field. Table 4 shows that sibling gender composition does not impact educational enrollment in or completion of any type of post-compulsory, vocational, or college education.[28] Consequently, these results demonstrate that sibling gender composition does not affect educational achievement or attainment, supporting an interpretation that changes in interests are the channel for the effects of sibling gender.

4.3 Labor Market Outcomes

Table 5
STEM Occupation and Annual Labor Earnings Percentile by Cohort

	STEM Occupation			Earnings Percentile		
Age	30 (1)	35 (2)	40 (3)	30 (4)	35 (5)	40 (6)
Sample of First-Born Women						
Second-Born	-0.23**	-0.30***	-0.40***	-0.30**	-0.41***	-0.38***
Brother	(0.11)	(0.11)	(0.12)	(0.14)	(0.14)	(0.14)
Same Sex Baseline	3.5	4.3	4.4	45.7	46.0	47.7
Percent Effect	-6.5	-6.9	-9.0	-0.7	-0.9	-0.8
Observations	120,621	119,967	119,034	120,621	119,967	119,034
Sample of First-Born Men						
Second-Born	0.08	0.12	0.35*	-0.18	-0.32**	-0.29*
Sister	(0.17)	(0.19)	(0.18)	(0.17)	(0.15)	(0.16)
Same Sex Baseline	8.8	11.8	12.1	63.3	63.6	62.5
Percent Effect	0.9	1.0	2.9	-0.3	-0.5	-0.5
Observations	126,983	126,354	124,933	126,983	126,354	124,933

All estimates are multiplied by 100 to express effects in percentage/percentile points. Standard errors in parentheses, clustered at the year-month of birth level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Main sample (first-born children with a younger biological sibling born within four years apart) restricted to cohorts born between 1962 and 1977. Each Panel-Column presents estimates from separate regressions. All models absorb fixed effects for birth municipality, year-month of birth, spacing in months to younger sibling, second generation immigrant status, maternal age at birth, paternal age at birth, maternal level-field of education, paternal level-field of education, and age at last observation for the specific outcome. *Same Sex Baseline* reports the mean outcome for individuals with a same sex sibling. *Percent Effect* reports the estimated effect of sibling gender relative to the baseline. *STEM Occupation* indicates whether mode occupation in a five year period through the indicated age is within STEM. *Earnings Percentile* is the percentile by cohort and age at the population level in annual labor earnings.

[28]Neither do I find any effect on the probability of ever completing grade 9 (not reported).

If the effects of sibling gender are truly due to changed interests, we would expect to see the effects on STEM choice to persist into labor market outcomes —and in particular, into occupational choice. To study this, I follow people well into their mid-career by observing their occupational choice and annual labor earnings at age 30, 35, and 40. I restrict the main sample to cohorts born between 1962 and 1977; however, the results for the age 30 outcomes are similar when including all cohorts. I define an individual to have a high-skilled STEM occupation if the mode occupation in a five year period up to the indicated age is within STEM fields.[29] Moreover, I consider the effects on the annual earnings percentile by age and cohort.[30]

Table 5 provides the results on labor market outcomes. The first three columns show the effect of sibling gender on the probability of being employed in a STEM occupation. For women, the effects on STEM education clearly persist into occupational choice. Women with a younger brother are respectively 6.5 and 9.0 percent less likely to work in a STEM occupation at age 30 and 40. Thus, the changes in educational STEM participation carry into the labor market for women. In contrast, sibling gender composition does not consistently affect men's probability of working within STEM.

The results further show clear negative consequences of having a brother relative to a sister for women's earnings [Columns (4) to (6)].[31] This finding is not surprising, given the previous results of lower participation in (higher paying) field-specific STEM educations and STEM occupations. Similarly, Cools and Patacchini (2017) show that in the U.S., women with any brother earn less around age 30. Their estimated effect is, however, much larger in magnitude, which might be explained by differences in the degree of gender equality between Denmark and the U.S. Consistent with previous studies on sibling gender composition and earnings, the results in Table 5 further indicates that having a younger sister decreases men's earnings, although this finding is less robust than the one for women. This negative impact of having a younger sister on male earnings might be explained by a larger degree of educational mismatch given the effect on STEM enrollment does not persist into STEM completion.

[29] I use the Danish version of the International Standard Classification of Occupations (DISCO) to determine high-skilled STEM occupations, which I define as subfields 21, 25, 31, and 35.

[30] The advantage of this measure is that it provides a standardized measure of relative earnings that includes individuals with zero earnings and is comparable across cohorts and ages.

[31] Sibling gender composition has no effect on cumulated work experience or unemployment at the different ages for men or women (not reported).

5 Mechanisms

5.1 Possible Mechanisms

So far, I have documented that the sibling gender composition in a family does matter for the formation of interests in STEM fields, especially for women. But *why* does sibling gender change men and women's likelihood of participating in STEM fields? —fields that are gender-stereotypical for men and the opposite for women. To investigate this question further, this subsection draws on the literature to identify relevant mechanisms, while the subsequent subsections provide some empirical evidence. Overall, I consider changes in identity to be the channel of the altered interests. The overarching argument is that individuals with an opposite sex sibling are more exposed to gender-stereotypical behavior and are therefore more inclined to acquire traditional gender norms.[32] In this context, gender-stereotypical behavior could become more salient either through changes in the nature of child-sibling or child-parent interactions, including parental investments.[33]

First, parents might interact differently with their children depending on the gender composition in terms of quantity, quality, and content of time spent together. Assuming that both parents spend at least some time with their children, a traditional household specialization model suggests that parents gender-specialize their investment in children when having mixed sex children if mothers are more productive in creating female human capital and fathers are more effective in creating male human capital (Becker, 1973). Parents might also derive more utility from spending time with a same compared to an opposite sex child due to the type of activities done with the child. In both cases, parents of mixed sex children would gender-specialize, to a greater extent, than parents of same sex children.

McHale et al. (2003) suggest that because parents of mixed gender children have the opportunity to gender-differentiate their parenting, children with opposite gender siblings might have the strongest explicit gender-stereotypes. Endendijk et al. (2013) find some evidence that fathers with mixed sex children exhibit stronger gender-stereotypical attitudes than fathers with same sex children. Previous research has further documented that, overall, mothers talk more in general and more about interests and attitudes with daughters than sons (Maccoby, 1990; Leaper et al., 1998; Noller and Callan, 1990). Fathers, in contrast, talk more and spend more time with sons than daughters and have a greater emotional attachment to sons (Bonke and

[32] Empirically, I do not find any effect of sibling gender on personality traits [Big Five, growth mindset, trust, hedonism] or mental health [Strength and Difficulties Questionnaire (SDQ)] (not reported), based on the DALSC sample introduced in Subsection 5.2.

[33] Appendix A.3 provides a short overview of alternative mechanisms discussed in previous papers on sibling gender composition. These mechanisms are, however, not compatible with the empirical findings.

Esping-Andersen, 2009; Morgan et al., 1988; Noller and Callan, 1990). Fathers are, furthermore, more likely to impose gender-stereotypical expectations on their sons than daughters and fathers dislike more often cross-gender-typed behavior among boys than do mothers (Burge, 1981; Freeman, 2007; Raag and Rackliff, 1998). Thus, these different pieces of evidence suggest that parents of mixed sex children gender-specialize their parenting more and thereby expose children to more gender-stereotypical behavior.

Second, the child and its sibling might interact differently depending on their gender composition. In particular, having a sibling of the opposite gender might make children more aware of "appropriate" behavior for their own gender and induce them to develop more gender-stereotypical attitudes and interests. Several studies have, for instance, shown that the presence of opposite gender peers increases gender-typed behavior in preschoolers [for references, see Raag and Rackliff (1998)]. The overall mechanism is in line with the same sex education literature, arguing that children, especially girls, acquire less gender-stereotypical interests when being together with same gender children only (Booth et al., 2014; Schneeweis and Zweimüller, 2012). Therefore, having a sibling of the opposite gender might induce individuals —particularly women —to develop more gender-stereotypical preferences for STEM fields due to a greater awareness of gender through sibling interactions. This in turn might be reinforced by parents' increased gender-specialization. In particular, Cools and Patacchini (2017) show that women with at least one brother develop more traditional gender attitudes relative to those with sisters only.

In sum, a particularly important mechanism for the observed effect of sibling gender on interests in STEM fields —that is possible to test for empirically—is differences in child-parent interactions. In the remainder of this section, I explore this mechanism in five different ways. First, in the daily child-parent interactions, we might observe that parents of mixed sex children invest more quality time in their same sex child. Second, this might cause differences in the quality of the relationship between the child and its mother and father, respectively. Third, we might observe that mixed sex children exhibit more or are to a larger extent exposed to gender-stereotypical behavior due to differential parental behavior. Fourth, in the extreme case of parental divorce, we might expect that mixed sex children would be more likely to live with their same sex parent compared to same sex children due to a larger degree of gender-specialized parenting. Fifth, if parents gender-specialize their parenting more when having mixed sex children, we would expect the effects of sibling gender on STEM preferences to be stronger for individuals with a more gender-stereotypical same gender parent, as more gender-stereotypical parents transfer more traditional preferences to their same sex children than less gender-stereotypical parents (Humlum et al., 2017). Thus, common for these predictions is that a parent of mixed sex children influences his or her same gender child more than a parent of same sex children.

5.2 Parental Time Investment

To investigate whether sibling gender composition affects child-parent interactions —and in particular, whether it affects parents' quality time investment—I draw on the Danish Longitudinal Survey of Children (DALSC).[34] The sample consists of 6,011 randomly sampled children born between September 15 and October 31, 1995 to a mother with Danish citizenship. The survey consists of five waves (1996, 1999, 2003, 2007, and 2011) and is unique due to its very detailed information on family socio-economic characteristics, family structure, and parental time use. For this analysis, I select first-born children who have a second-born sibling born within five calendar years apart.[35] At age 7 and 11, both parents report how often they do different types of activities together with the child. I construct a parental quality time investment index, using principal component analysis, and standardize it with mean zero and standard deviation of one. I define quality time as playing with the child, helping with homework, doing out-of-school activities, reading/singing, and going on an excursion.

Columns (1) through (4) in Table 6 provide the results on parental time investment by each parent for the two ages, separately. Mothers of a first-born daughter and a second-born son invest more time in their first-born daughter at both ages compared to mothers with two daughters. The increase is in the magnitude of 15 percent of a standard deviation, corresponding to spending 0.7 activities more each week with the daughter. In contrast, fathers invest 20 percent of a standard deviation less time in their first-born daughter when having mixed sex children. This reduction in total paternal time investment is driven by decreased time spent helping with homework and reading for the daughter [Appendix Table A6]. This finding could indicate that girls with a younger brother receive less qualified help with STEM-related homework, which might prevent them from growing interests in these fields. Overall, girls receive the same amount of time investment regardless of their younger sibling's gender. These results clearly show that first-born girls with a second-born brother experience more gendered parenting.

For boys, the overall picture is similar. Mothers of mixed sex children invest less time in their first-born son relative to mothers with two sons. This reduction in mothers' time spent with sons is mainly driven by a decrease in time spent playing with the son [Appendix Table A6]. In contrast, sibling gender composition does not affect

[34] The study was designed by researchers from SFI, the Danish National Centre for Social Research, in collaboration with other research institutions.

[35] I only observe the year of birth of siblings and do therefore not have more precise information on the spacing. Restricting spacing to four years as for the main analysis gives similar results, although the smaller sample size reduces the precision of the estimates.

Table 6
Parental Time Investment and Housework at Age 7 and 11

	Parental Time Investment				Housework w Parents	
	Mother		Father			
	Age 7 (1)	Age 11 (2)	Age 7 (3)	Age 11 (4)	Age 7 (5)	Age 11 (6)
Sample of First-Born Girls						
Second-Born	0.14*	0.16*	-0.15*	-0.21**	0.01	-0.04
Brother	(0.08)	(0.09)	(0.09)	(0.09)	(0.09)	(0.10)
Average	0.04	-0.00	-0.08	-0.08	0.05	0.11
Observations	657	616	470	453	485	448
Sample of First-Born Boys						
Second-Born	-0.15**	-0.18**	-0.08	-0.05	-0.17**	0.02
	(0.08)	(0.08)	(0.09)	(0.10)	(0.09)	(0.09)
Average	-0.04	0.00	0.07	0.08	-0.05	-0.11
Observations	694	645	514	460	533	452

Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. DALSC sample. Each Panel-Column represents the results from separate regressions. All models control for mother's and father's age (squared) and fixed effects for spacing to the younger sibling in years, parental marital status in 1996, parents having been together for at least 5 years in 1996, region of birth, maternal level of education, paternal level of education, and family income level in 1995. *Parental time investment* is constructed using principal component analysis based on reports on how often each parent does certain quality time activities (playing, doing homework, doing out-of-school activities, reading/singing, going on an excursion) together with the child at a weekly basis (see Appendix Table A5). *Housework with parents* is an index on how much the parents involve the child in housework activities (cooking, domestic chores) at a weekly basis (see Appendix Table A5). All outcomes variables are standardized with mean zero and standard deviation of one.

fathers' total time investment in boys. This, however, masks some important findings when considering the individual components of the index: fathers of mixed sex children play less with their first-born son but seem to help more with homework and to read to the son relative to fathers with two sons [Appendix Table **??**]. Consequently, first-born boys with a second-born sister receive, on average, less total parental time investment, driven by less time spent playing. This might help explain why the effect of sibling gender does not persist into actual STEM graduation if boys are more responsive in their STEM pursuit to any decline in parental inputs relative to girls, regardless of the composition of the decline. Despite an overall decrease in parental time investment in sons, the findings still demonstrate that first-born boys with a second-born sister receive proportionally more male inputs.

Table 7

Quality of Child-Parent and Child-Sibling Relations

	Mother's	Fathers'	Child's relationship to		
	Relationship to Child		Mother	Father	Siblings
Child Age	11/15	7	15	15	15
	(1)	(2)	(3)	(4)	(5)
Sample of First-Born Girls					
Second-Born	-0.08	-0.23***	-0.01	-0.20**	-0.37***
Brother	(0.10)	(0.09)	(0.09)	(0.10)	(0.09)
Average	0.01	0.02	0.08	-0.06	0.09
Observations	494	485	558	547	537
Sample of First-Born Boys					
Second-Born	0.08	0.05	-0.09	0.01	-0.17**
Sister	(0.09)	(0.09)	(0.08)	(0.07)	(0.09)
Average	-0.01	-0.01	-0.08	0.06	-0.08
Observations	513	529	596	587	565

Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. DALSC sample. Each Panel-Column represents the results from separate regressions. All models control for mother's and father's age (squared) and fixed effects for spacing to the younger sibling in years, parental marital status in 1996, parents having been together for at least 5 years in 1996, region of birth, maternal level of education, paternal level of education, and family income level in 1995. All child-parent relationship indexes represent the first component from principal component analyses shown in Appendix Table A7, are standardized such that a higher value reflects a better relationship, the mean is zero, and the standard deviation is one. *Child's relationship to siblings* is an index of how easy the child thinks it is to talk to his/her siblings about matters that really bother him/her (standardized with mean zero and standard deviation of one).

Given the findings on parents' differential investment in first-born children by the second-born's gender, sibling gender might also affect the relationship between the child and its parents and siblings and thereby the strength of the transmission of parental preferences. Although measured at different ages, DALSC asks the mother, father, and child how each person perceives their relationship to the child/each parent. From these questions, I construct indexes based on principal component analysis with higher values reflecting better relationships [see Appendix Table A7]. Each index is standardized to have mean zero and standard deviation of one. Table 7 shows that fathers perceive the relationship to their first-born daughter worse at age 7 when having a second-born son compared to fathers with two daughters. Similarly, first-born girls with a second-born brother report worse quality of the relationship to their father at age 15. Meanwhile, sibling gender does not affect the relationship between parents and sons. Lastly, both first-born girls and boys report a worse relationship to their siblings when having a second-born opposite sex sibling, suggesting that sibling gender composition also affects child-sibling interactions.

Finally, I consider whether first-born boys and girls are differentially affected by having a younger sibling of the opposite sex in terms of exposure to female-typed activities. I construct an index measuring the extent to which parents involve the child in housework activities (cooking and other domestic chores reported by each parent), which are traditionally perceived as female-typed activities. Sibling gender does not affect girls' involvement in housework with parents [Table 6, Columns (5) and (6)]. In contrast, at age 7, first-born boys with a second-born sister are significantly less involved in housework activities. This difference in housework involvement fades out by age 11, though. These results suggest that boys with a younger sister at young ages are more exposed to gender-stereotypical behavior than those with a brother.[36]

In conclusion, these analyses support the hypothesis that parents of mixed sex children gender-specialize their parenting more than parents of same sex children.

5.3 Family Structure at Age 17

In the extreme case of parental divorce or separation (henceforth *divorce*), the living arrangement between parents and children might additionally help shed light on child-parent interactions in the main sample. If parents of mixed sex children gender-specialize more than parents of same sex children, first-born children with a second-born opposite sex sibling might be more likely to live with their same sex parent (*SSP*) in case of parental divorce. Moreover, a family living arrangement where the oldest child lives with the same sex parent and the younger child lives with the opposite sex parent

[36] An alternative interpretation is that boys exhibit more gender-stereotypical behavior. However, I cannot test for this distinction.

(OSP) might be more prevalent. Yet, sibling gender composition might also affect the likelihood of living in a traditional family, defined as living with both biological parents. Table 8 studies how sibling gender composition affects family structure at age 17 for the main sample.[37] From this, it is clear that sibling gender composition does not alter the probability of living in a traditional family at age 17, neither for women nor for men [Columns (1) and (4), respectively].

Table 8
Family Structure at Age 17

	First-Born Women			*First-Born Men*		
Sample	All	Non-Traditional		All	Non-Traditional	
First-Born lives w	Both parents (1)	SSP (2)	SSP, sib w OSP (3)	Both parents (4)	SSP (5)	SSP, sib w OSP (6)
Second-Born Opposite Sex	-0.04	0.91**	5.23***	-0.07	0.47	3.55***
	(0.18)	(0.39)	(0.27)	(0.20)	(0.47)	(0.38)
Same Sex Baseline	78.6	78.2	4.4	79.1	29.2	13.8
Percent Effect	-0.1	1.2	119.6	-0.1	1.6	25.7
Observations	162,564	34,922	34,745	171,416	35,913	35,736

All estimates are multiplied by 100 to express effects in percentage points. Standard errors in parentheses, clustered at the year-month of birth level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Main sample (first-born children with a second-born biological sibling born within four years apart), born 1962–1986. Each Column presents estimates from separate regressions. All models absorb fixed effects for birth municipality, year-month of birth, spacing in months to younger sibling, second generation immigrant status, maternal age at birth, paternal age at birth, maternal level-field of education, paternal level-field of education, and age at observation of family structure. *Same Sex Baseline* reports the mean outcome for individuals with a same sex sibling. *Percent Effect* reports the estimated effect of sibling gender relative to the baseline. *All* includes everybody who lives with at least one biological parent, while *Non-Traditional* excludes those living with both biological parents. *SSP* indicates that the firstborn child lives with its biological same sex parent. *SSP, sib w OSP* indicates that the first-born child lives with its same sex parent and the second-born child lives with the opposite sex parent (opposite sex compared to the first child's gender).

Conditional on living in a non-traditional family, the results show a pattern consistent with the predictions. First-born girls with a second-born brother are more likely to live with their mother [Column (2)]. Furthermore, both first-born men and women with a second-born opposite sex sibling are more likely to live in a living arrangement in which they live with their same sex parent and their younger sibling lives with the

[37] I observe the family structure on January 1st each year and use the observation for the year the person turns 18 years or the last year in which the child lives with at least one biological parent.

opposite sex parent [Columns (3) and (6)]. For women (men) the estimated effect is 5.2 (3.6) percentage points, corresponding to an increase of 120 (26) percent relative to the mean for women (men) with a same sex sibling. These results consequently show a strong effect on the living arrangement among non-traditional families and thereby support the previous findings (based on the much smaller DALSC sample) on more gender-specific parenting and time investment in families with mixed sex children.

5.4 Heterogeneity

Table 9

Field-Specific STEM Education: Heterogeneity by Parental Field

Sample of	*First-Born Women*		*First-Born Men*	
	Enroll-ment (1)	Comple-tion (2)	Enroll-ment (3)	Comple-tion (4)
Second-Born	-0.08	-0.21	0.62	0.08
Opposite Sex (SBOS)	(0.20)	(0.15)	(0.38)	(0.34)
SBOS × Mom Admin	-1.41***	-0.71*	-1.00	-0.69
	(0.49)	(0.38)	(0.75)	(0.68)
SBOS × Mom Health	-0.66**	-0.63***	-0.04	-0.13
	(0.29)	(0.22)	(0.53)	(0.48)
SBOS × Dad STEM	-0.05	-0.08	0.76*	0.88**
	(0.28)	(0.22)	(0.45)	(0.42)
N	164,632		173,262	

All estimates are multiplied by 100 to express effects in percentage points. Standard errors in parentheses, clustered at the year-month of birth level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Main sample (first-born children born 1962–1986 with a second-born biological sibling born within four years apart). Each Column presents estimates from separate regressions. All models absorb fixed effects for birth municipality, year-month of birth, spacing in months to younger sibling, second generation immigrant status, maternal age at birth, paternal age at birth, maternal level-field of education, paternal level-field of education, age at last educational observation, and the parental fields, which are interacted with SBOS. *Same Sex Baseline* reports the mean outcome for individuals with a same sex sibling. *Percent Effect* reports the estimated effect of sibling gender relative to the baseline. *Field-specific STEM* education refers to vocational and college programs within STEM excluding Biology.

Finally, this subsection studies heterogeneity in the effects of sibling gender composition on STEM preferences and ties the findings to the discussion on mechanisms. Table 9 explores heterogeneity by parents' field. For women, the effects are strongest among those with a mother who has a heavily female-dominated education or occupation, i.e. within either administration (e.g. secretary and office work) and health (e.g. nursing). In contrast, for men, the effects are concentrated among those with a father within STEM. Thus, those individuals who have a same sex parent with gender-specific human capital are the ones driving the effect of sibling gender. Meanwhile, having a gender-stereotypical opposite sex parent seems unimportant for heterogeneity in the effect.[38] This is consistent with the hypothesis that same sex parents of mixed sex children invest more time in their same sex child than parents of same sex children, as we would expect that parents with more gender-stereotypical human capital would reinforce gender-specialization to a larger extent than those parents with less gender-specific human capital. Additionally, Appendix Table A9 shows that the effect on field-specific STEM enrollment is particularly large for men who come from families where the parents have a traditional division of labor during childhood. Consequently, these heterogeneities indicate that differences in child-parent interactions are important for the effects of sibling gender composition on STEM interests.

Expanding the sample to include individuals spaced up to 15 years from their second-born sibling shows that sibling gender only affects STEM education for first-born women with spacing of less than five years and less than three years for men [Appendix Table A10; Appendix Figure A5]. Meanwhile, the estimated effects by spacing are not statistically significantly different from each other, probably due to the small fraction of children with very long spacing to their second-born sibling. This finding that individuals with long spacing to their younger sibling do not experience an effect of sibling gender might indicate the importance of sibling interactions. However, it could also be because parents with children spaced far apart treat the first-born child similarly regardless of the younger sibling's gender.[39]

6 Robustness Checks

6.1 Family Size

As discussed in Section 2, sibling gender composition affects family size but family size does not seem to strongly affect STEM participation (Appendix A.2). However, to further test the robustness of the main results to family size, this subsection applies three different strategies: 1) to flexibly control for family size, 2) to divide the sample by family size, and 3) to study the effect of having a co-twin of the opposite sex.

[38] Appendix Table A8 shows heterogeneity by parental length of education. The effects are, generally, concentrated among individuals with a high educated (≥ 12 years of schooling) same sex parent.

[39] Despite large changes in society over these 25 birth cohorts, the effects do not differ systematically by decade of birth (Appendix Table A11). This is consistent with the finding by Haines et al. (2016) that gender-stereotypes have not changed over the last three decades in the U.S.

Although family size is endogenous to sibling gender composition, strategies (1) and (2) are useful to the degree that they informs about the sensitivity of the results. These robustness analyses, together with the evidence of no differential effect by sibling gender on educational attainment and the supplementary analysis of the effect of family size on STEM participation, provide convincing evidence that family size does not confound the effects of sibling gender composition.

The first strategy, controlling for family size, may bias the estimates of sibling gender because family size is an outcome of sibling gender composition. Yet, one could also view family size as an omitted variable if family size has an independent effect on STEM participation. In Table 10, the first row in each panel repeats the main results, while the second row shows the estimates of sibling gender when flexibly accounting for family size.[40] Overall, the estimates are extremely similar.

The second strategy is to split the sample by family size.[41] However, given family size is endogenous, this robustness check comes with a selection problem. If those parents of same sex children (born at the first two parities) who have a third child are more gender-stereotypical and influence their children's outcomes in such direction than those who do not have a third child, we would expect the effect of having a second-born opposite sex sibling to be larger in magnitude among first-born children from two-child families than for the entire sample. Similarly we would expect the effect of sibling gender to be smaller among children from families with at least three children. This is exactly what the results in the third and fourth rows show in Table 10. In fact, the estimates for the sample with at least two siblings are much smaller in magnitude and insignificant in most cases.[42]

Finally, to circumvent potential confounding effects from family size, I examine the effect of having a co-twin of the opposite gender as an alternative empirical strategy.[43] The key empirical feature of the sample of twins is that twin gender composition only has a very limited impact on family size [Column (1)], especially for twins born at the first parity. Overall, the effects of having a co-twin of the opposite gender on STEM choice, both for the sample of all twins and twins born at the first parity, are very similar to the main results [Appendix Table A12]. The magnitude of the effects is, however, much larger. This might be due to the much greater intensity of the exposure to a co-twin compared to a younger sibling.

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[40] I flexibly account for family size by including dummies for the number of biological siblings and dummies for the number of children the mother and father potentially have, respectively, from later relationships.

[41] I restrict the sample to individuals who only have biological siblings, i.e. none of their parents have children with another person than the parent; though the results are similar when including those with half-siblings.

[42] However, the insignificance might partly be due to smaller sample sizes.

[43] This approach is similar to the one in Cronqvist et al. (2015) and Peter et al. (2015), except that I do not have information on zygocity.

Table 10

STEM Education: Controlling for and Splitting by Family Size

	Field-Specific STEM				Academic HS		Vocational STEM		College STEM	
	Enrollment		Completion		STEM Track		(Any Level)		Excl. Biology	
	Excl. Biology (1)	Incl. Biology (2)	Excl. Biology (3)	Incl. Biology (4)	Enroll-ment (5)	Com-pletion (6)	Enroll-ment (7)	Com-pletion (8)	Enroll-ment (9)	Com-pletion (10)
Sample of First-Born Women										
Main Estimates	-0.48***	-0.51***	-0.53***	-0.58***	-0.91***	-0.87***	-0.18*	-0.18***	-0.37***	-0.36***
($N = 164,733$)	(0.14)	(0.15)	(0.10)	(0.11)	(0.22)	(0.19)	(0.11)	(0.07)	(0.10)	(0.08)
Family Size Controls	-0.50***	-0.53***	-0.55***	-0.59***	-0.87***	-0.82***	-0.21*	-0.19***	-0.37***	-0.36***
($N = 164,733$)	(0.14)	(0.15)	(0.10)	(0.11)	(0.22)	(0.19)	(0.11)	(0.07)	(0.10)	(0.08)
1 Sibling	-0.70***	-0.71***	-0.78***	-0.81***	-1.08***	-0.96***	-0.24*	-0.22**	-0.52***	-0.56***
($N = 93,285$)	(0.20)	(0.21)	(0.14)	(0.16)	(0.27)	(0.25)	(0.14)	(0.09)	(0.15)	(0.11)
2+ Siblings	-0.28	-0.33	-0.34**	-0.42**	-0.71*	-0.77**	-0.09	-0.13	-0.32*	-0.21
($N = 54,634$)	(0.23)	(0.24)	(0.17)	(0.18)	(0.37)	(0.34)	(0.17)	(0.11)	(0.18)	(0.13)
Sample of First-Born Men										
Main Estimates	0.80***	0.77***	0.32	0.33	0.22	0.12	0.53**	0.26	0.33**	0.09
($N = 173,340$)	(0.23)	(0.23)	(0.22)	(0.22)	(0.23)	(0.19)	(0.22)	(0.20)	(0.15)	(0.13)
Family Size Controls	0.66***	0.63***	0.18	0.18	0.19	0.11	0.39*	0.12	0.32**	0.08
($N = 173,340$)	(0.23)	(0.23)	(0.22)	(0.22)	(0.23)	(0.19)	(0.22)	(0.20)	(0.15)	(0.13)
1 Sibling	1.02***	1.01***	0.59*	0.59*	0.38	0.40	0.73**	0.54**	0.38*	0.09
($N = 96,248$)	(0.32)	(0.32)	(0.31)	(0.31)	(0.30)	(0.26)	(0.30)	(0.27)	(0.21)	(0.18)
2+ Siblings	0.15	0.07	-0.20	-0.19	0.02	-0.10	-0.16	-0.33	0.27	0.14
($N = 59,556$)	(0.40)	(0.40)	(0.37)	(0.37)	(0.35)	(0.32)	(0.38)	(0.34)	(0.25)	(0.22)

All estimates are multiplied by 100 to express effects in percentage points. Standard errors in parentheses, clustered at the year-month of birth level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Main sample (first-born children born 1962–1986 with a second-born biological sibling born within four years apart). Each cell presents estimates from separate regressions. All models absorb fixed effects for birth municipality, year-month of birth, spacing in months to younger sibling, second generation immigrant status, maternal age at birth, paternal age at birth, maternal level-field of education, paternal level-field of education, and age at last educational observation. *Family Size Controls*-models further include dummies for the number of biological siblings and dummies for the number of children the mother and father potentially have, respectively, from later relationships. *1 Sibling*-models restrict the sample to those who only have one full sibling and no half-siblings. *2+ Siblings*-models restrict the sample to those who have at least two full siblings and no half-siblings.

6.2 The Effect of an Older Sibling's Gender

Despite the potential problems with selection bias from estimating the effect of an older sibling's gender, as discussed in Section 2, we would still expect the direction of the effect on STEM participation to be the same. Such analysis can thus serve as a robustness check. Considering the potential bias, suppose that parents who have a certain gender-preference are more likely to have a second child when their first-born child is of the non-preferred gender and that these parents treat their children more gender-stereotypically. In such case, the estimate of the first-born child's gender would be upward biased. Appendix Table A13 shows the results from an analysis of the associations between having an older opposite sex sibling and STEM participation for a sample of second-born children. Overall, these results are similar to the main results on STEM education. However, for men, the effects on any field-specific STEM enrollment and completion are around three times larger than for the main results, which might both be due to selection bias and to a role model effect of the older sibling. These results are also closer to the ones in Anelli and Peri (2014) who do not find a significant effect for women although the magnitude of their estimate (-1.3 percentage point for enrollment in a high earnings college major) is larger than my corresponding estimate (-0.2 percentage points for enrollment in a STEM excluding Biology college major).

6.3 Alternative Measures of Field of Study

As a final test of the robustness of the main findings, I consider alternative measures of field of study. First, I use OECD (2016)'s definition of STEM to include Natural Sciences, Mathematics, Statistics, Information and Communication Technologies, Engineering, Manufacturing, and Construction (ISCED fields 51–73). Compared to my preferred definition of STEM, this alternative definition includes Biology, Manufacturing, and Construction and excludes Economics. Appendix Table A14 shows that the results for this alternative definition are very similar to the main findings [Columns (1) to (4)]. Second, instead of considering traditionally male-dominated fields, I consider care fields (Education, Health, and Welfare; ISCED fields 11, 91, and 92), which are traditionally female-dominated. The results on choosing an education within care fields stress the main finding that having an opposite sex sibling makes both men and women's interests more gender-stereotypical [Columns (5) to (8)]. These results demonstrate larger percent effects, due to a lower baseline, for men than women and compared to the main results on STEM choice and display a more consistent finding that men with a younger sister are more likely to opt out of female-typed fields. Third, I consider the narrow field of the highest completed education by age 30 (28 mutually exclusive groups). For women [Appendix Figures A7], the negative effect of having a younger brother on STEM completion is driven by Economics and Engineering.[44]

7 Conclusion

This study documents that the family environment has a powerful long-run impact on especially women's participation in traditionally male-dominated STEM fields. The results suggest that having an opposite sex sibling increases the probability of choosing a gender-stereotypical field of education. Women opt out of STEM already at the time of their first active educational choice at the end of 9^{th} grade. Men, on the contrary, show an increased interest in STEM fields, but are not more likely to complete a STEM education. The altered participation in STEM fields persist into occupational choice for women and has negative consequences for their earnings. An important mechanism for these findings is the effect on child-parent interactions. Parents with mixed sex children gender-specialize their parenting more and invest more quality time in their same sex child than parents with same sex children.

My findings emphasize that if policy makers want to increase the number of people —and particularly women—within STEM fields, they need to focus on early educational choices made already at the end of compulsory schooling. However, attention to decisions at this educational stage is not sufficient. As my analysis of mechanisms stresses, the family —representing a central aspect of the social environment —influences the formation of STEM preferences throughout childhood. Moreover, no evidence shows that men possess an inherent advantage over women in math ability: boys and girls start school with similar math performance; yet, around the time of puberty, the gender difference in average math performance (favoring boys) stabilizes (Kahn and Ginther, 2017). This suggests that social environmental factors influence the way in which boys and girls develop interests and abilities within STEM fields already during early school grades. Consequently, if society wants to give boys and girls the same opportunities in terms of labor market performance in adulthood, policy makers would need to focus on how to counteract the transmission of gender norms across generations and thereby the development of gender-stereotypical behaviors, attitudes, and preferences.

[44] Appendix Figure A8 shows the corresponding results for men without any consistent pattern.

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A Appendix

A.1 The Selection Bias Problem

To show the selection bias problem more formally, I here follow Peter et al. (2015). Assume a latent outcome $Y_i^* = \alpha + \beta G_i^{old} + X_i' \gamma + \epsilon_i$, where G_i^{old} is the gender of the older sibling and X_i is a vector of observable exogenous characteristics. ϵ_i contains other relevant unobservable variables, such as parental gender preferences denoted by P_i, and $E[\epsilon_i] = 0$. The bias arises because of the latent nature of Y_i^*, as we only observe the outcome if child i is born. In other words, $Y_i = Y_i^*$ if the child is born ($S_i = 1$) and Y_i is missing if the child is not born ($S_i = 0$). The selection depends both on parental preferences and the older child's gender, $S_i = f(P_i, G_i^{old})$. We can only estimate the effect for the sample of children who are born which gives the expected value of Y_i:

$$E[Y_i|S_i = 1, G_i^{old}, X_i] = \alpha + \beta G_i^{old} + \gamma X_i + E[\epsilon_i|S_i = 1, G_i^{old}, X_i] \quad (2)$$

$$= \alpha + \beta G_i^{old} + \gamma X_i + E[\epsilon_i|f(P_i, G_i^{old}) = 1, G_i^{old}, X_i].$$

As long as selection depends on the first child's gender and parental preferences affect the way in which parents raise their children $E[\epsilon_i|f(P_i, G_i^{old}) = 1, G_i^{old} = 1, X_i] \neq E[\epsilon_i|f(P_i, G_i^{old}) = 1, G_i^{old} = 0, X_i]$. This implies that the estimate of the older sibling's gender is biased.

A selection problem could also arise in the absence of parental gender preferences. Assume that first-born children have n normally-distributed traits, such as how easy the child is to take care of and how well it behaves. Suppose parents only want a second child if their first child has a value of each trait above a certain threshold. The threshold for or the distribution of each trait could be gender-specific. In both cases, parents who progress to the next parity would, on average, have different types of first-born children depending on the child's gender. For instance, if boys and girls have the same distribution of how well they behave but parents require girls to behave better than boys to have a second child, second-born children would, on average, have a better behaving older sibling if they have a sister compared to a brother. In this example, the estimated effect of the older sibling's gender on the younger child's outcomes might thus be due to the older sibling's behavior rather than due to his or her gender.

A.2 Does Family Size affect STEM Education?

Black et al. (2005) use twins as an instrument for family size to show that family size does not affect educational attainment, using Norwegian registry data; Angrist et al. (2010) find the same for Israel. However, they only consider length of schooling and

Table A1

Family Size and STEM Education using Twins as Instrument

	First Stage	Second Stage				
	# of Siblings	Years of education	Field-spec STEM		College STEM	
			Enroll-ment	Com-pletion	Enroll-ment	Com-pletion
	(1)	(2)	(3)	(4)	(5)	(6)
Sample of First-Born Women ($N = 166,213$)						
Twins at 2^{nd} parity	0.74***					
	(0.018)					
# of Siblings		0.03	-0.87	-1.13*	-0.15	-0.93*
		(0.07)	(0.92)	(0.63)	(0.76)	(0.52)
F-statistic of IV	1735.29					
Prob>F	< 0.001					
Average	1.6	13.5	8.5	4.8	4.7	2.9
Effect×0.07		0.00	-0.06	-0.08	-0.01	-0.07
Percent effect×0.07		0.02	-0.72	-1.66	-0.23	-2.22
Sample of First-Born Men ($N = 175,032$)						
Twins at 2^{nd} parity	0.72***					
	(0.016)					
# of Siblings		-0.11	-0.67	0.81	0.25	-0.01
		(0.08)	(1.58)	(1.56)	(1.01)	(0.88)
F-statistic of IV	2042.57					
Prob>F	< 0.001					
Average	1.7	13.3	41.2	28.7	12.7	8.3
Effect×0.08		-0.01	-0.05	0.06	0.02	0.00
Percent effect×0.08		-0.07	-0.13	0.22	0.16	-0.01

All estimates for binary outcomes (enrollment and completion) are multiplied by 100. Standard errors in parentheses, clustered at the year-month of birth level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Main sample including twin siblings born at second parity (first-born children born 1962–1986 with a second-born biological sibling born within four years apart). Each Column presents estimates from separate regressions. All models absorb fixed effects for birth municipality, year-month of birth, spacing in months to younger sibling, second generation immigrant status, maternal age at birth, paternal age at birth, maternal level-field of education, paternal level-field of education, and age at last educational observation. *# of Siblings* measures the total number of siblings the individual has, including full and half siblings. The effects are multiplied by 0.07 (*Effect×0.07*) for women and by 0.08 for men, because these are the effects of having an opposite sex sibling on the number of siblings.

not the probability of enrolling in or completing a field-specific STEM degree. In this supplementary analysis, I show, consistent with their findings, employing a similar strategy in the Danish context, that family size does not affect educational attainment or field-specific STEM enrollment.

I use a sample with similar sample restrictions as for the main sample (see Subsection 3.1) with the exception that I include firstborn singleton children who have younger twin siblings born at the second parity.[45] The instrument for family size is having twins at the second parity. Column (1) in Appendix Table A1 shows that the instrument is strong and relevant; see Angrist et al. (2010) and Black et al. (2005) for a discussion of the validity of the instrument.

Columns (2) to (6) show the second stage results. Similar to the findings for Norway and Israel, family size does not affect the length of highest completed education by age 30. Neither does it significantly impact the probability of any field-specific or college STEM enrollment, although the point estimates are not tight zeros. Moreover, family size does not significantly affect men's probability of STEM completion. Meanwhile, the effect of family size is borderline statistically significantly negative for women, suggesting that having more siblings reduces the probability of completing any STEM degree. This might suggest that for women the estimates of having a younger brother on STEM completion in the main analysis are conservative. This potential downward bias would, however, only be small, as first-born women with a second-born sister, on average, have 0.07 more siblings than first-born women with a second-born brother. This is what the statistic *Effect*$\times$ *0.07* illustrates in the table.

A.3 Alternative Mechanisms

This appendix describes alternative mechanisms to the ones discussed in Subsection 5.1. These mechanisms are, however, not compatible with the empirical findings.

The effect of sibling interactions might also go in the opposite direction for two reasons. First, the spillover model in developmental psychology hypothesizes that siblings imitate and influence each other with their gender-specific traits. For instance, Brim (1958) and Koch (1955) show that mixed sex siblings exhibit more traits of the opposite gender and fewer of their own gender compared to same sex sibling pairs. Second, the reference group theory in sociology suggests that as soon as a same sex sibling is present in the family, the same sex sibling will be the child and parents' reference group (Butcher and Case, 1994). Therefore, having a same sex sibling might induce the child to behave more gender-stereotypically.

Studies examining the relationship between sibling gender composition and educational attainment have argued that budget constraints may play an important role

[45] I include all multiple birth; twins, however, represent the vast majority of all multiple births.

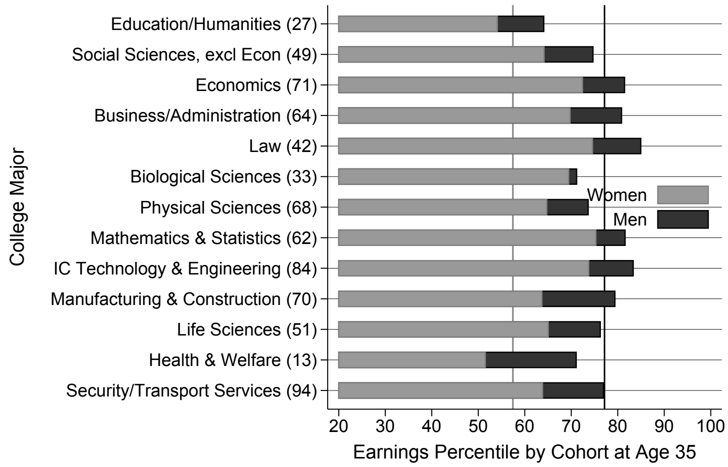
(Amin, 2009; Butcher and Case, 1994). If parents face no borrowing constraints, they should, according to standard economic theory, invest in each child until marginal costs equal marginal benefits. However, if parents face borrowing constraints, they might decide to allocate their financial resources depending on the gender composition of their children. If parents want income equality between their children and the returns to education are smaller for women than men, then having a brother instead of a sister would be beneficial. However, parental aversion to income inequality cannot be the dominating channel, as we would otherwise have observed that having a sibling of the opposite gender should make the educational choice less gender-stereotypical.

In contrast, parents might want to maximize the total income of their children, thereby investing more in the child with the greatest returns to education. If returns to education are larger for men than women, having a brother would have adverse effects on educational attainment. In support of this argument, Powell and Steelman (1989) find for students enrolled in one college in the U.S. that the number of brothers puts more pressure on parents' financial support than do the number of sisters. Nevertheless, this is not a likely mechanism in the Danish context because there is no tuition fee at any educational level. Moreover, students in vocational training typically receive apprenticeship wages and students in tertiary education receive governmental student grants and loans to cover living expenses. For all cohorts in the analysis, students in tertiary education have at least had access to a combination of grants and loans of 1,000 USD a month in 2017-prices. It is also less clear how borrowing constraints should affect field choice, given sibling gender composition has no effect on the probability of enrolling in any type of program after compulsory education. Moreover, a more recent study shows that, for later generations in the U.S., parents to at least one son compared to parents with no sons do not differentially invest in their daughters (Cools and Patacchini, 2017).

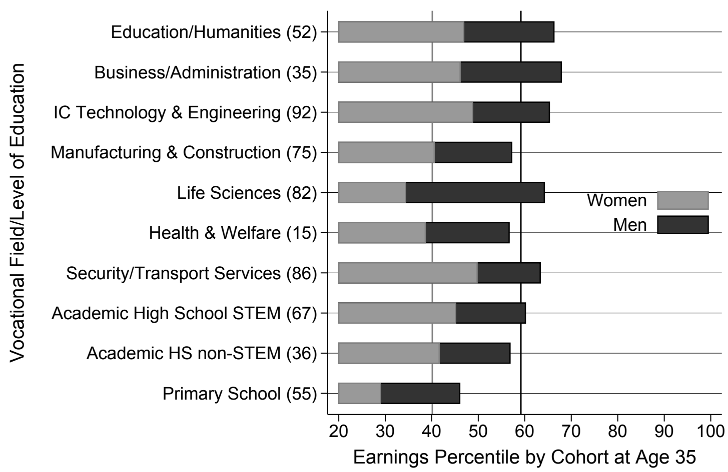
A.4 Appendix Figures and Tables

Figure A1

Average Earnings Percentile at age 35 by Field and Type of Education



(a) College Major

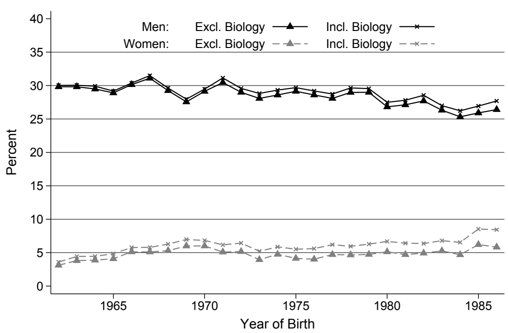


(b) Vocational Field/Level of Education

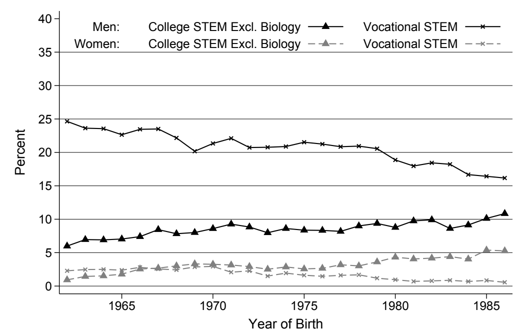
Note: Main sample (first-born children born 1962–1986 with a second-born biological sibling born within four years apart). Both graphs show separately by gender the average earnings percentile by birth cohort at age 35 by field and level of highest completed education by age 30. The number shown in parenthesis for each field label indicates the proportion of men in the specific group. The vertical lines indicate the mean earnings percentile for women (gray) and men (black) in each graph.

Figure A2

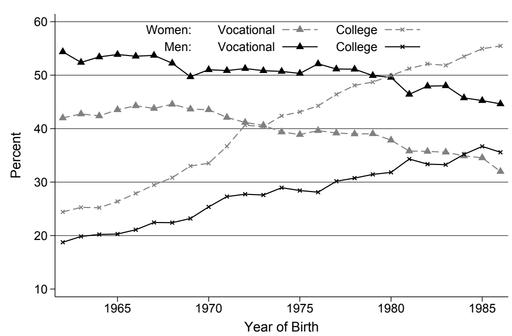
Educational Attainment at Age 30 by Gender Across Cohorts



(a) STEM excl. and incl. Biology



(b) College vs. Vocational STEM Degree

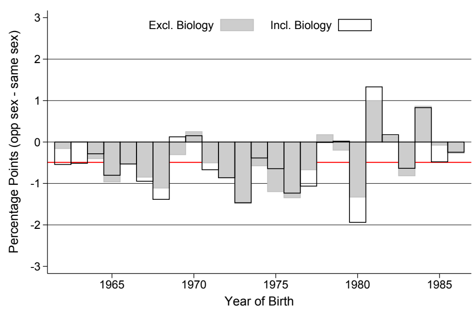


(c) Degree Type

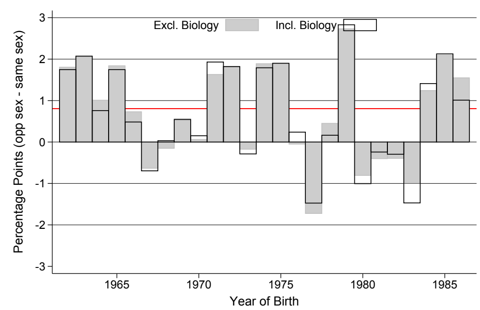
Note: Main sample (first-born children born 1962–1986 with a second-born biological sibling born within four years apart). Graph (a) illustrates the share of a cohort by gender completing a field-specific STEM degree, excluding and including Biology in the definition of STEM. Graph (b) illustrates the share of a cohort completing a STEM vocational and STEM excluding Biology college degree by gender. Graph (c) illustrates the share of a cohort by gender completing at least vocational (secondary/tertiary) education and at least college education, respectively.

Figure A3

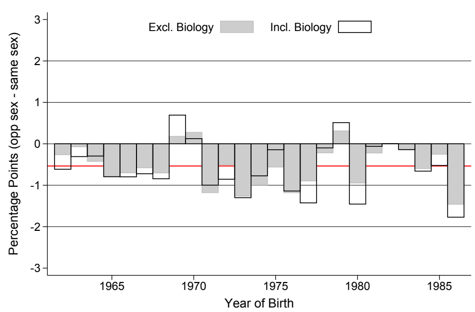
Field-Specific STEM Enrollment and Completion by Gender Across Cohorts: Opposite-Same Sex Sibling Differences



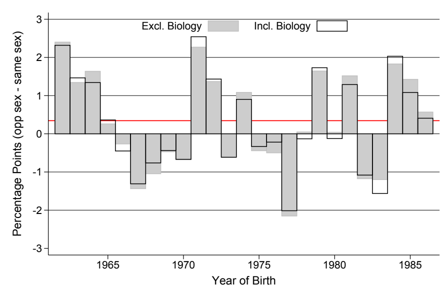
(a) First-born Women: Enrollment



(b) First-born Men: Enrollment



(c) First-born Women: Completion

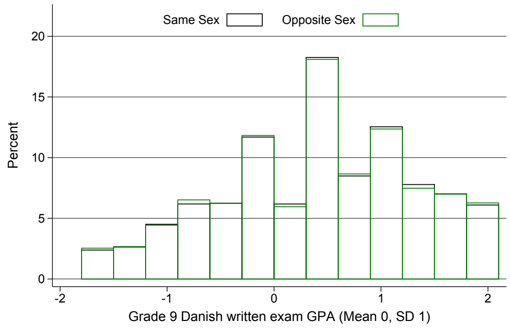


(d) First-born Men: Completion

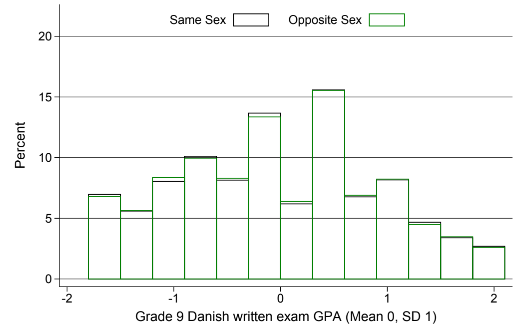
Note: Main sample (first-born children born 1962–1986 with a second-born biological sibling born within four years apart). Graphs (a) and (b) illustrate, by cohort, the raw difference between the share of individuals who enroll in a field-specific STEM program excluding (gray) and including (white) Biology with an opposite sex sibling and those with a same sex sibling for women and men, respectively. Graphs (c) and (d) illustrate, by cohort, the raw difference between the share of individuals who complete a field-specific STEM program excluding (gray) and including (white) Biology with an opposite sex sibling and those with a same sex sibling for women and men, respectively. The red, horizontal line in each graph represents the mean difference in STEM excluding Biology across cohorts.

Figure A4

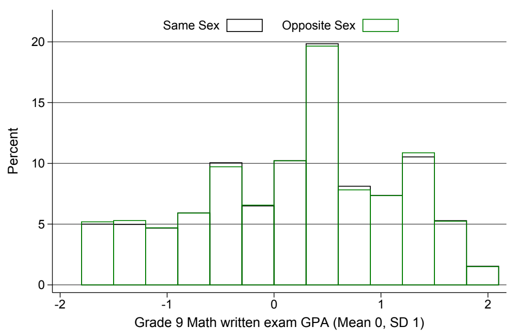
Distribution of Ability by Sibling Gender Composition



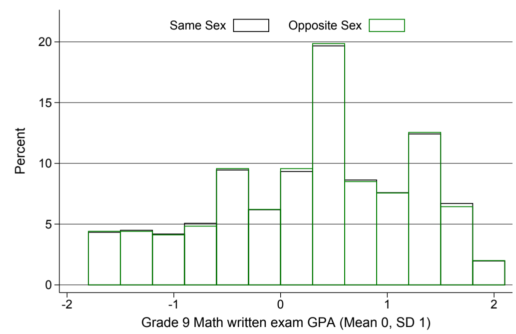
(a) Girls: Grade 9 Danish written exam



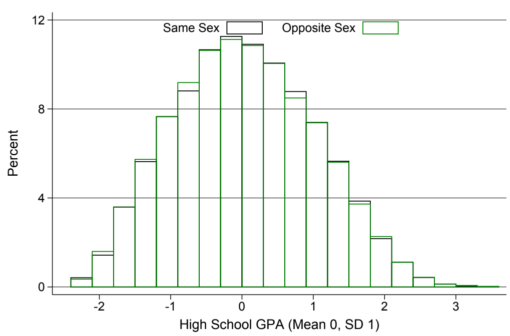
(b) Boys: Grade 9 Danish written exam



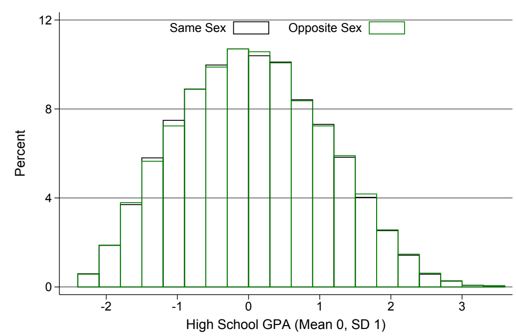
(c) Girls: Grade 9 Math written exam



(d) Boys: Grade 9 Math written exam



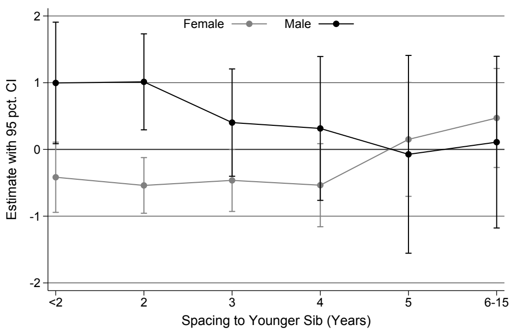
(e) Women: Academic HS GPA



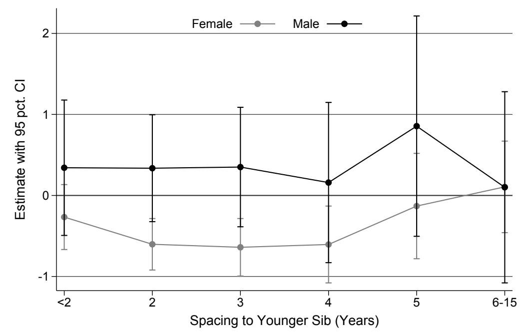
(f) Men: Academic HS GPA

Note: Main sample (first-born children born 1962–1986 with a second-born biological sibling born within four years apart) for academic high school GPA; children born between 1986 and 1999 with the same selection criteria as for the main sample for the grade 9 outcomes. The Grade 9 GPA measures come from the written exam at the end of grade 9 in respectively Danish and Math. *Academic HS GPA* is observed for students completing the academic high school; before 1999, this is only observed for those in the language and math tracks. The standardized GPA measures are standardized by year of graduation (for the high school GPA track-by-year of graduation) for the total population with mean zero and standard deviation of one. All graphs plot the distribution of the three measures of school performance by individuals with a same sex (black) and with an opposite sex sibling (green), respectively. The tails are truncated in order to have at least five observations within each cell.

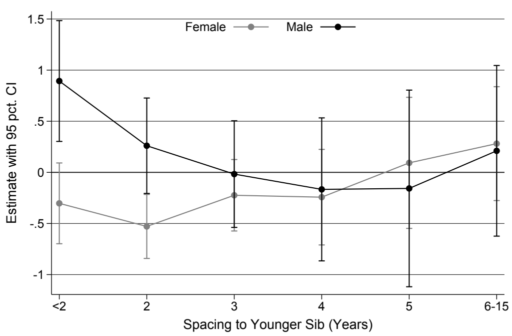
Figure A5
STEM Education by Spacing



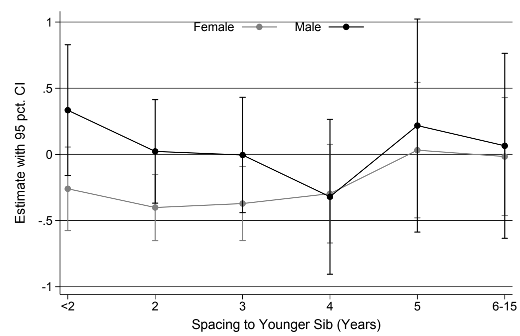
(a) Field-Specific STEM Enrollment



(b) Field-Specific STEM Completion



(c) STEM (excl. Bio.) College Enrollment

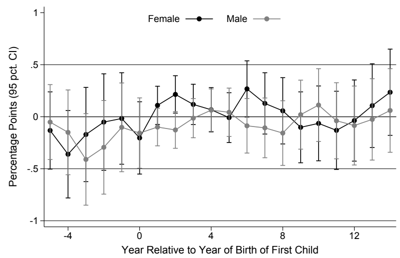


(d) STEM (excl. Bio.) College Completion

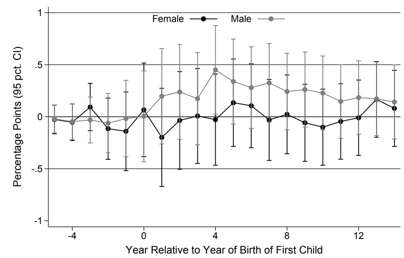
Note: Main sample (first-born children born 1962–1986) including individuals with a second-born biological sibling born up to 15 years apart. All graphs illustrate the estimated effect of having an opposite sex sibling by birth spacing; the estimates come from separate regressions by gender and are also displayed Appendix Table A10. The whiskers represent the 95 percent confidence interval.

Figure A6

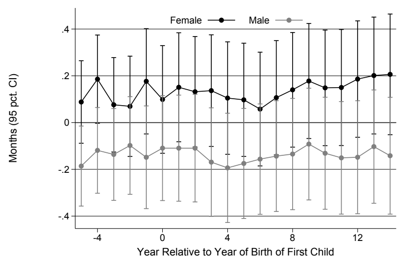
Family Structure and Parental Education, Employment, and Earnings



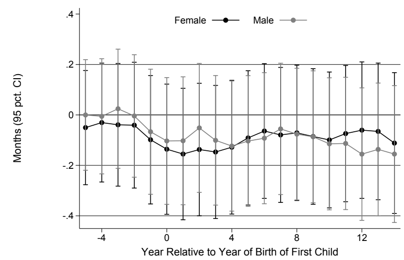
(a) Parents Cohabit/are Married



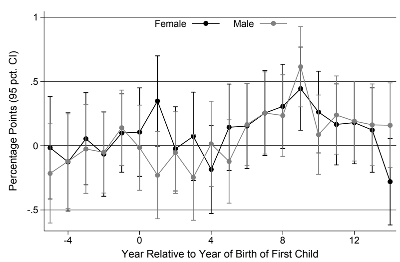
(b) Parents are Married



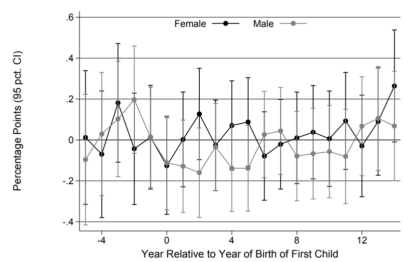
(c) Mother's Edu (months)



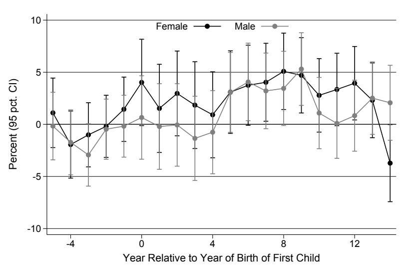
(d) Father's Edu (months)



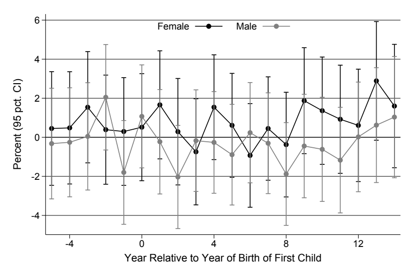
(e) Mother Employed



(f) Father Employed



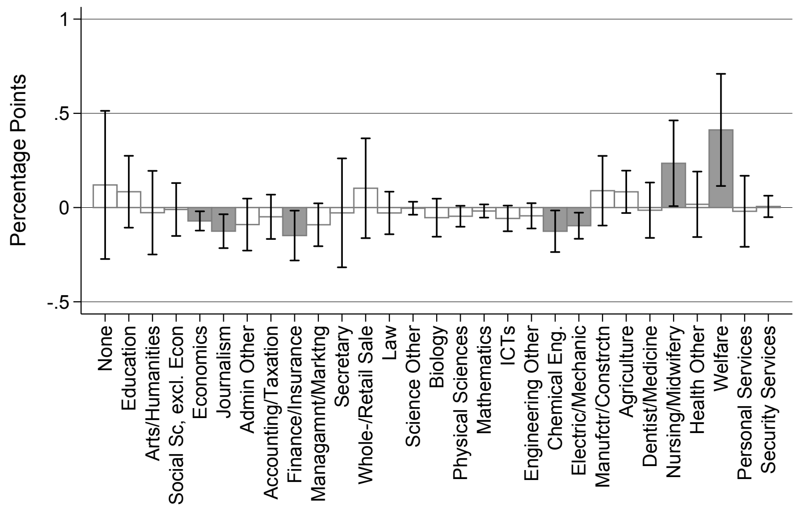
(g) Mother's Log(earnings)



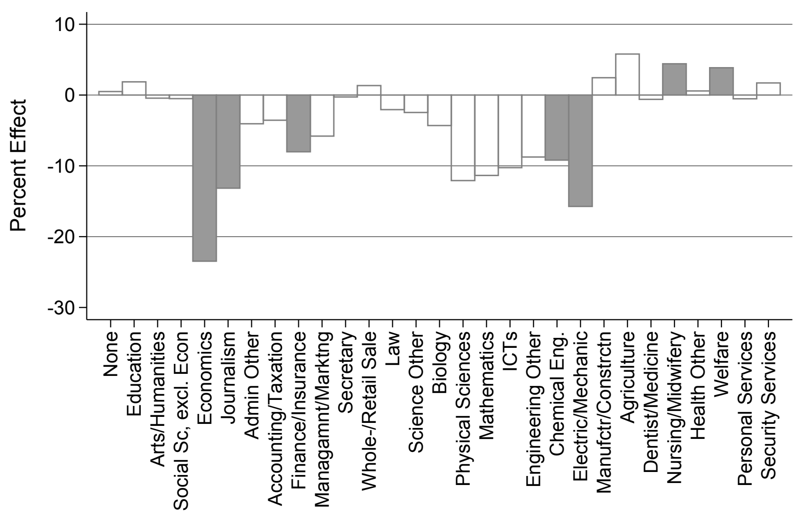
(h) Father's Log(earnings)

Note: Sample of first-born children born between 1985 and 2002 with a second-born biological sibling born within four years apart. The whiskers represent the 95 percent confidence interval. All graphs illustrate the estimates from an event study of the effect of having a second-born child of the opposite sex by gender of the first-born child. All models absorb time-specific fixed effects for birth municipality, year-month of birth, spacing in months to younger sibling, second generation immigrant status, maternal age at birth, paternal age at birth, maternal level-field of education, and paternal level-field of education.

Figure A7
Women: Narrow Field of Highest Completed Education



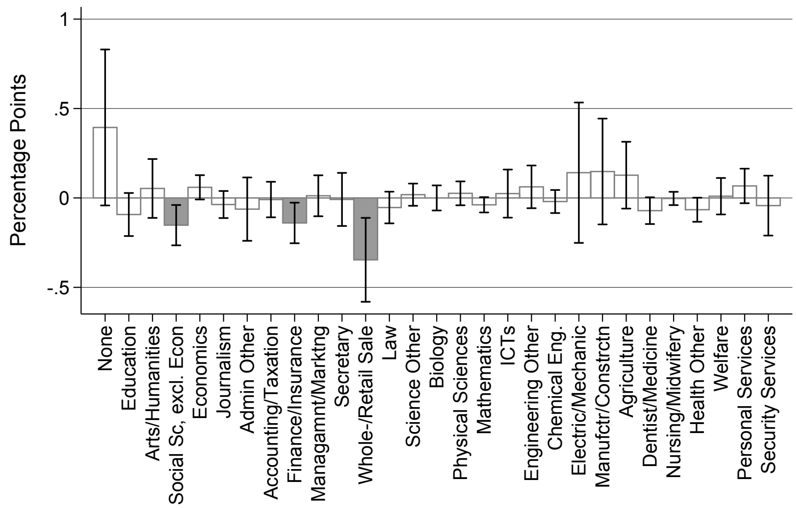
(a) Estimate w 95 pct. CI



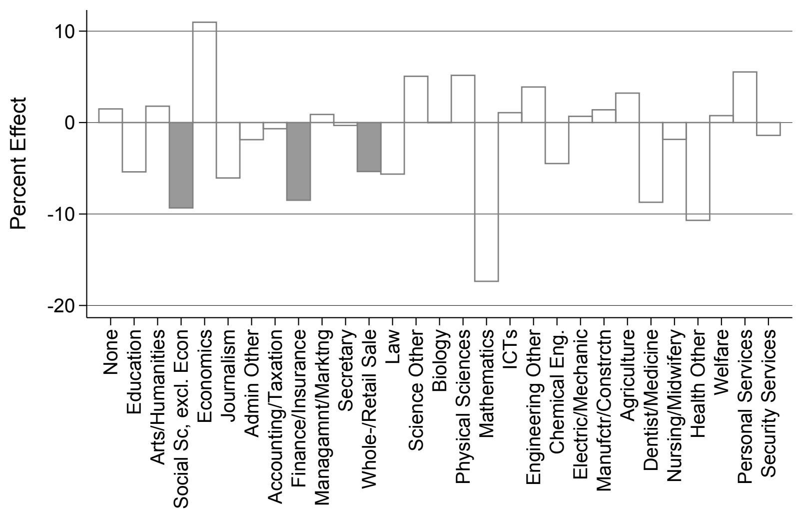
(b) Percent Effect

Note: Women in main sample (first-born daughters born 1962–1986 with a second-born biological sibling born within four years apart). Each bar represents the estimate from a separate regression. All models absorb fixed effects for birth municipality, year-month of birth, spacing in months to younger sibling, second generation immigrant status, maternal age at birth, paternal age at birth, maternal level-field of education, and paternal level-field of education. Graph (a) shows the estimates measured in percentage points together with the 95 percent confidence interval. Graph (b) shows the percent effect evaluated relative to the mean for individuals with a same sex sibling. Each outcome indicates whether the highest completed education by age 30 is within the indicated field.

Figure A8
Men: Narrow Field of Highest Completed Education



(a) Estimate w 95 pct. CI



(b) Percent Effect

Note: Men in main sample (first-born daughters born 1962–1986 with a second-born biological sibling born within four years apart). Each bar represents the estimate from a separate regression. All models absorb fixed effects for birth municipality, year-month of birth, spacing in months to younger sibling, second generation immigrant status, maternal age at birth, paternal age at birth, maternal level-field of education, and paternal level-field of education. Graph (a) shows the estimates measured in percentage points together with the 95 percent confidence interval. Graph (b) shows the percent effect evaluated relative to the mean for individuals with a same sex sibling. Each outcome indicates whether the highest completed education by age 30 is within the indicated field.

Table A2

Sibling Gender Composition and Number of Siblings

Sample of	*First-Born Women*			*First-Born Men*		
	# of Siblings	≥ 2 Siblings	≥ 3 Siblings	# of Siblings	≥ 2 Siblings	≥ 3 Siblings
	(1)	(2)	(3)	(4)	(5)	(6)
Second-Born	-0.07***	-4.96***	-1.43***	-0.08***	-6.89***	-1.33***
Opposite Sex	(0.00)	(0.22)	(0.13)	(0.00)	(0.23)	(0.13)
Same Sex Baseline	1.7	38.1	8.5	1.7	40.1	8.4
Percent Effect	-4.2	-13.0	-16.9	-4.7	-17.2	-15.8
Observations		164,733			173,340	

All estimates are multiplied by 100 to express effects in percentage points. Standard errors in parentheses, clustered at the year-month of birth level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Main sample (first-born children born 1962–1986 with a second-born biological sibling born within four years apart). Each Column presents estimates from separate regressions. All models absorb fixed effects for birth municipality, year-month of birth, spacing in months to younger sibling, second generation immigrant status, maternal age at birth, paternal age at birth, maternal level-field of education, and paternal level-field of education. *Same Sex Baseline* reports the mean outcome for individuals with a same sex sibling. *Percent Effect* reports the estimated effect of sibling gender relative to the baseline. *# of Siblings* measures the total number of siblings the individual has, including full and half siblings. $\geq 2(3)$ *Siblings* takes the value one if the person has at least two (three) full siblings and zero otherwise.

Table A3

Different Control Versions: Field-Specific STEM Enrollment and Completion

	Excluding Biology			*Including Biology*		
	No controls	Controls excl. parental education	All controls	No controls	Controls excl. parental education	All controls
	(1)	(2)	(3)	(4)	(5)	(6)
Sample of First-Born Women: Enrollment						
Second-Born Brother	-0.49***	-0.48***	-0.48***	-0.53***	-0.51***	-0.51***
	(0.14)	(0.14)	(0.14)	(0.15)	(0.15)	(0.15)
Sample of First-Born Women: Completion						
Second-Born Brother	-0.54***	-0.53***	-0.53***	-0.58***	-0.57***	-0.58***
	(0.10)	(0.10)	(0.10)	(0.11)	(0.12)	(0.11)
Sample of First-Born Men: Enrollment						
Second-Born Sister	0.81***	0.80***	0.80***	0.77***	0.77***	0.77***
	(0.23)	(0.23)	(0.23)	(0.23)	(0.23)	(0.23)
Sample of First-Born Men: Completion						
Second-Born Sister	0.34	0.32	0.32	0.34	0.32	0.33
	(0.22)	(0.22)	(0.22)	(0.22)	(0.22)	(0.22)

All estimates are multiplied by 100 to express effects in percentage points. Standard errors in parentheses, clustered at the year-month of birth level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Main sample (first-born children born 1962–1986 with a second-born biological sibling born within four years apart). Each cell presents estimates from separate regressions. All models include a constant. Models with the control version *Controls excl. parental education* absorb fixed effects for birth municipality, year-month of birth, spacing in months to younger sibling, second generation immigrant status, maternal age at birth, paternal age at birth, and age at last educational observation. Models with *All controls* further include fixed effects for maternal level-field of education and paternal level-field of education (i.e. a replication of the results in Table 2.)

Table A4

Educational Performance

Sample of	*First-Born Girls*			*First-Born Boys*		
	Grade 9 written exam		Academic	Grade 9 written exam		Academic
	Danish	Math	HS	Danish	Math	HS
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Standardized GPA (Population Mean 0, SD 1)						
Second-Born	-0.009	-0.009	-0.009	0.002	0.004	0.009
Opposite Sex	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.008)
Average	0.411	0.191	0.042	-0.031	0.288	0.064
Observations	87,070	86,383	85,524	88,631	88,465	58,608
Panel B: Probability of having GPA observation (multiplied by 100)						
Second-Born	-0.077	-0.177	-0.237	-0.278	-0.215	-0.159
Opposite Sex	(0.175)	(0.181)	(0.220)	(0.196)	(0.197)	(0.200)
Average	91.4	90.7	51.9	87.6	87.4	33.8
Observations	95,226	95,226	164,733	101,223	101,223	173,340

Standard errors in parentheses, clustered at the year-month of birth level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Main sample (first-born children born 1962–1986 with a second-born biological sibling born within four years apart) for academic high school GPA; children born between 1986 and 1999 with the same selection criteria as for the main sample for the grade 9 outcomes. Each Panel-Column presents estimates from separate regressions. All models absorb fixed effects for birth municipality, year-month of birth, spacing in months to younger sibling, second generation immigrant status, maternal age at birth, paternal age at birth, maternal level-field of education, and paternal level-field of education. The Grade 9 GPA measures come from the written exam at the end of grade 9 in respectively Danish and Math. *Academic HS GPA* is observed for students completing the academic high school; before 1999, this is only observed for those in the language and math tracks. The standardized GPA measures are standardized by year of graduation (for the high school GPA track-by-year of graduation) for the total population with mean zero and standard deviation of one.

Table A5

Principal Component Analysis: Parental Time Investment and Housework

	Mother's Investment		Father's Investment		Housework Parents	
Child Age	7	11	7	11	7	11
First Principal Component						
Play with Child	0.52	0.52	0.48	0.55		
Help with Homework	0.35	0.44	0.47	0.45		
Out-of-school Activity	0.44	0.37	0.40	0.48		
Read or Sing for Child	0.47	0.46	0.42	0.37		
Go on an Excursion	0.44	0.43	0.46	0.36		
Cook with Father					0.43	0.54
Domestic Chores with Father					0.52	0.57
Cook with Mother					0.49	0.45
Domestic Chores with Mother					0.55	0.42
Eigenvalues						
First Component	1.55	1.58	1.82	1.76	1.48	1.50
Second Component	0.97	1.04	0.90	1.05	1.19	1.31

DALSC sample. All questions are answered on a 4-point likert scale (higher values reflect more often). A higher value reflects greater investment/involvement.

Table A6

Components of Parental Time Investment at Age 7 and 11

	Age 7					Age 7				
	Play	Home-work	Out-of-School Activity	Read/ Sing	Excur-sion	Play	Home-work	Out-of-School Activity	Read/ Sing	Excur-sion
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Sample of First-Born Girls: Maternal Investment										
Second-Born	0.11	0.08	-0.00	0.07	0.16**	0.11	0.13	-0.00	0.13	0.08
Brother	(0.08)	(0.07)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.09)	(0.08)	(0.09)
Average	-0.04	0.15	0.01	0.01	0.02	0.03	-0.08	0.06	-0.04	0.04
Observations	665	662	660	665	665	621	620	619	619	621
Sample of First-Born Girls: Paternal Investment										
Second-Born	-0.06	-0.16*	-0.02	-0.19**	0.03	-0.18*	-0.20**	-0.07	-0.10	-0.05
Brother	(0.09)	(0.09)	(0.08)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
Average	-0.07	0.03	-0.21	-0.05	0.01	-0.02	-0.01	-0.15	-0.06	-0.02
Observations	494	482	484	495	493	456	458	457	457	457
Sample of First-Born Boys: Maternal Investment										
Second-Born	-0.15**	-0.06	-0.12	-0.06	0.02	-0.22***	0.02	-0.05	-0.09	-0.11
Sister	(0.08)	(0.08)	(0.08)	(0.07)	(0.08)	(0.08)	(0.08)	(0.07)	(0.08)	(0.08)
Average	0.03	-0.14	-0.01	-0.01	-0.02	-0.03	0.08	-0.06	0.04	-0.04
Observations	709	699	704	709	709	648	648	645	648	648
Sample of First-Born Boys: Paternal Investment										
Second-Born	-0.23***	0.08	-0.09	0.07	-0.12	-0.01	0.01	-0.18*	0.10	-0.03
Sister	(0.09)	(0.09)	(0.10)	(0.08)	(0.09)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
Average	0.07	-0.02	0.19	0.04	-0.01	0.02	0.01	0.14	0.06	0.02
Observations	543	522	532	542	541	468	466	465	466	467

Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. DALSC sample. Each Panel-Age-Column represents the results from separate regressions. All models control for mother's and father's age (squared) and fixed effects for spacing to the younger sibling in years, parental marital status in 1996, parents having been together for at least 5 years in 1996, region of birth, maternal level of education, paternal level of education, and family income level in 1995. *Same Sex Baseline* reports the mean outcome for individuals with a same sex sibling. *Percent Effect* reports the estimated effect of sibling gender relative to the baseline. Each of the individual components of maternal time investment is measured as the total number of activities done together with the child at a weekly basis.

Table A7

Principal Component Analysis: Child-Parent Relations

	Mother's	Fathers'	Child's relationship to	
	Relationship to Child		Mother	Father
Child Age	11/15	7	15	15
First Principal Component				
Age 11: How close is the relationship between you and your son/daughter (1–4)?	0.707			
Age 15: How close is the relationship between you and your son/daughter (1–3)?	0.707			
Age 7: How close is the relationship between you and your son/daughter (1–4)?		0.707		
Age 7: Are you satisfied with the relationship between you and your son/daughter (1(yes)–2(no))?		0.707		
Age 15: Your mother/father plays a very big role in your life (1–5)			0.314	0.358
Age 15: Your relationship with your mother/father is important to you (1–5)			0.363	0.379
Age 15: Your mother/father loves you (1–5)			0.357	0.351
Age 15: You trust your mother/father (1–5)			0.396	0.398
Age 15: You can expect your mother/father to listen to you (1–5)			0.407	0.393
Age 15: You can go to your mother/father for advice (1–5)			0.406	0.375
Age 15: You can count on help from your mother/father if you have a problem (1–5)			0.395	0.388
Eigenvalue				
First Component	1.335	1.348	3.568	4.329
Second Component	0.665	0.652	1.004	0.754

DALSC sample. All questions are answered on a likert scale with lower values being better. Therefore, the standardized measures used in Table 7 are all reversed, such that a higher value reflects a better relationship.

Table A8
Field-Specific STEM Enrollment and Completion: Heterogeneity by Length of Parental Education

	STEM Enrollment		STEM Completion	
	Excl. Biology (1)	Incl. Biology (2)	Excl. Biology (3)	Incl. Biology (4)
Sample of First-Born Women				
Opp$\times M_{<HS}, F_{<HS}$	0.23	0.14	-0.13	0.03
	(0.25)	(0.17)	(0.15)	(0.10)
Opp$\times M_{\geq HS}, F_{<HS}$	-0.73	-0.81**	-0.52*	-0.58**
	(0.45)	(0.35)	(0.31)	(0.25)
Opp$\times M_{<HS}, F_{\geq HS}$	-0.46*	-0.59***	-0.05	-0.23*
	(0.27)	(0.19)	(0.18)	(0.13)
Opp$\times M_{\geq HS}, F_{\geq HS}$	-0.74***	-0.74***	-0.64***	-0.57***
	(0.23)	(0.19)	(0.20)	(0.17)
Observations	156,953			
Sample of First-Born Men				
Opp$\times M_{<HS}, F_{<HS}$	0.43	0.49	0.17	0.22
	(0.51)	(0.43)	(0.21)	(0.16)
Opp$\times M_{\geq HS}, F_{<HS}$	0.13	-0.23	1.23***	0.13
	(0.76)	(0.70)	(0.46)	(0.38)
Opp$\times M_{<HS}, F_{\geq HS}$	1.06**	0.38	0.11	-0.20
	(0.51)	(0.46)	(0.27)	(0.22)
Opp$\times M_{\geq HS}, F_{\geq HS}$	0.94***	0.48	0.49*	0.32
	(0.35)	(0.33)	(0.28)	(0.25)
Observations	165,547			

All estimates are multiplied by 100 to express effects in percentage points. Standard errors in parentheses, clustered at the year-month of birth level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Main sample (first-born children born 1962–1986 with a second-born biological sibling born within four years apart) for those with information on both parents' length of education. Each Panel-Column presents estimates from separate regressions. All models absorb fixed effects for birth municipality, year-month of birth, spacing in months to younger sibling, second generation immigrant status, maternal age at birth, paternal age at birth, maternal level-field of education, paternal level-field of education, indicators for the parents' combination of length of education, and age at last educational observation.

Table A9

Field-Specific STEM Enrollment and Completion: Heterogeneity by Parental Division of Labor

	STEM Enrollment		STEM Completion	
	Excl. Biology (1)	Incl. Biology (2)	Excl. Biology (3)	Incl. Biology (4)
Sample of First-Born Women				
Second-Born	-0.43**	-0.55***	-0.40***	-0.40***
Brother (SBB)	(0.17)	(0.12)	(0.13)	(0.10)
SBB×Traditional	-0.25	0.07	0.08	0.19
Division	(0.33)	(0.24)	(0.24)	(0.18)
Observations	162,575			
Sample of First-Born Men				
Second-Born	0.57**	0.21	0.26	0.10
Sister (SBS)	(0.26)	(0.25)	(0.17)	(0.15)
SBS×Traditional	1.26**	0.76	0.31	0.02
Division	(0.56)	(0.53)	(0.36)	(0.30)
Observations	171,082			

All estimates are multiplied by 100 to express effects in percentage points. Standard errors in parentheses, clustered at the year-month of birth level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Main sample (first-born children born 1962–1986 with a second-born biological sibling born within four years apart) for those with information of both parents' labor supply. Each Panel-Column presents estimates from separate regressions. All models absorb fixed effects for birth municipality, year-month of birth, spacing in months to younger sibling, second generation immigrant status, maternal age at birth, paternal age at birth, maternal level-field of education, paternal level-field of education, and age at last educational observation. *Traditional Division* takes the value one if paternal labor supply represents at least 75 percent of total parental labor supply during childhood and zero otherwise.

Table A10

Field-Specific STEM Enrollment and Completion: Heterogeneity by Spacing

Sample of	*First-Born Women*				*First-Born Men*			
	STEM Enrollment		STEM Completion		STEM Enrollment		STEM Completion	
	Excl. Biology (1)	Incl. Biology (2)	Excl. Biology (3)	Incl. Biology (4)	Excl. Biology (5)	Incl. Biology (6)	Excl. Biology (7)	Incl. Biology (8)
Opp × <2 years	-0.42	-0.27	-0.30	-0.26	1.00**	0.34	0.89***	0.33
	(0.27)	(0.20)	(0.20)	(0.16)	(0.46)	(0.43)	(0.30)	(0.25)
Opp ×2 years	-0.54**	-0.60***	-0.53***	-0.40***	1.01***	0.34	0.26	0.02
	(0.21)	(0.16)	(0.16)	(0.13)	(0.37)	(0.34)	(0.24)	(0.20)
Opp ×3 years	-0.46*	-0.64***	-0.22	-0.37***	0.40	0.35	-0.02	-0.00
	(0.24)	(0.18)	(0.18)	(0.14)	(0.41)	(0.38)	(0.27)	(0.22)
Opp ×4 years	-0.54*	-0.61**	-0.24	-0.30	0.31	0.16	-0.17	-0.32
	(0.32)	(0.24)	(0.24)	(0.19)	(0.55)	(0.50)	(0.36)	(0.30)
Opp ×5 years	0.15	-0.13	0.09	0.03	-0.07	0.86	-0.16	0.22
	(0.44)	(0.33)	(0.33)	(0.26)	(0.76)	(0.69)	(0.49)	(0.41)
Opp ×6–15 years	0.47	0.11	0.28	-0.02	0.11	0.10	0.21	0.07
	(0.38)	(0.29)	(0.28)	(0.23)	(0.66)	(0.60)	(0.43)	(0.36)
Observations	232,372				243,169			

All estimates are multiplied by 100 to express effects in percentage points. Standard errors in parentheses, clustered at the year-month of birth level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Main sample (first-born children born 1962–1986) including individuals with a second-born biological sibling born up to 15 years apart. Each Column presents estimates from separate regressions. All models absorb fixed effects for birth municipality, year-month of birth, spacing in months to younger sibling, second generation immigrant status, maternal age at birth, paternal age at birth, maternal level-field of education, paternal level-field of education, and age at last educational observation. *Opp* indicates having a second-born sibling of the opposite gender.

Table A11

Field-Specific STEM Enrollment and Completion: Heterogeneity by Decade of Birth

	STEM Enrollment		STEM Completion	
	Excl. Biology (1)	Incl. Biology (2)	Excl. Biology (3)	Incl. Biology (4)
Sample of First-Born Women				
Second-Born	-0.51**	-0.41***	-0.40***	-0.26**
Brother	(0.20)	(0.15)	(0.15)	(0.11)
SBB$\times 1970-79$	-0.20	-0.27	-0.03	-0.14
	(0.30)	(0.22)	(0.22)	(0.17)
SBB$\times 1980-86$	0.53	-0.07	0.17	-0.21
	(0.41)	(0.29)	(0.30)	(0.26)
Prob>F	0.216	0.442	0.809	0.594
Observations	164,733			
Sample of First-Born Men				
Second-Born	0.91**	0.34	0.15	-0.12
Sister	(0.36)	(0.33)	(0.24)	(0.20)
SBS$\times 1970-79$	-0.03	-0.12	0.30	0.29
	(0.50)	(0.46)	(0.32)	(0.28)
SBS$\times 1980-86$	-0.47	0.14	0.27	0.50
	(0.65)	(0.64)	(0.44)	(0.40)
Prob>F	0.748	0.915	0.627	0.391
Observations	173,340			

All estimates are multiplied by 100 to express effects in percentage points. Standard errors in parentheses, clustered at the year-month of birth level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Main sample (first-born children born 1962–1986 with a second-born biological sibling born within four years apart). Each Panel-Column presents estimates from separate regressions. All models absorb fixed effects for birth municipality, year-month of birth, spacing in months to younger sibling, second generation immigrant status, maternal age at birth, paternal age at birth, maternal level-field of education, paternal level-field of education, and age at last educational observation. *Prob>F* reports the p-value from an F-test of joint significance of opposite sex sibling interactions with decade of birth.

Table A12

Effect of Co-Twin's Gender

	Next Birth	Field-Specific STEM Enrollment	Field-Specific STEM Completion	STEM Focus in First Enrollment	STEM in Highest Completion
	(1)	(2)	(3)	(4)	(5)
Panel A: Female Twins					
	Any Parity ($N = 12,755$)				
Co-Twin Brother	-1.32**	-1.56***	-1.40***	-2.81***	-1.26***
	(0.60)	(0.51)	(0.38)	(0.82)	(0.36)
Same Sex Baseline	24.1	8.0	4.7	23.3	4.3
Percent Effect	-5.5	-19.6	-29.9	-12.1	-29.6
	First Parity ($N = 4,730$)				
Co-Twin Brother	-0.48*	-1.95**	-2.05***	-0.79	-1.79***
	(0.29)	(0.90)	(0.68)	(1.50)	(0.64)
Same Sex Baseline	42.0	8.5	5.4	26.1	4.7
Percent Effect	-1.1	-23.0	-37.9	-3.0	-37.7
Panel B: Male Twins					
	Any Parity ($N = 13,067$)				
Co-Twin Sister	-1.83***	2.89***	1.28	2.10**	1.71*
	(0.61)	(0.97)	(0.89)	(0.99)	(0.88)
Same Sex Baseline	23.6	37.2	26.0	46.1	24.9
Percent Effect	-7.8	7.8	4.9	4.6	6.9
	First Parity ($N = 4,832$)				
Co-Twin Sister	-0.58*	3.14*	1.46	2.56	1.32
	(0.31)	(1.68)	(1.54)	(1.72)	(1.52)
Same Sex Baseline	40.2	37.8	26.4	48.1	25.5
Percent Effect	-1.4	8.3	5.5	5.3	5.2

All estimates are multiplied by 100 to express effects in percentage points. Standard errors in parentheses, clustered at the mother level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Each Panel-Column-Sample presents estimates from separate regressions. The sample consists of twins born at respectively *any* and *first* parity. All models absorb fixed effects for birth county, year of birth, second generation immigrant status, mother's level and field of education, father's level and field of education, and age at last educational observation. The models further control for (cubed) mother's age at birth and (cubed) father's age at birth. The models for the *Any Parity*-sample further control for parity. *Next Birth* indicates if the parents get a subsequent child. *Same Sex Baseline* reports the mean outcome for individuals with a same sex co-twin. *Percent Effect* reports the estimated effect of co-twin gender relative to the baseline. *Field-Specific STEM* excludes Biology. *STEM Focus in First Enrollment* indicates whether the first place of enrollment after compulsory education is within STEM (vocational secondary or academic high school). *STEM in Highest Completion* indicates whether the highest completed education is a field-specific STEM education excluding biology.

Table A13

The Effect of an Older Sibling's Gender

	STEM Excluding Biology				Educational Attainment			
	Field-Specific		College		Vocational		College	
	Enrollment (1)	Completion (2)	Enrollment (3)	Completion (4)	Enrollment (5)	Completion (6)	Enrollment (7)	Completion (8)
Sample of Second-Born Women								
First-Born Brother	-0.29**	-0.17*	-0.21**	-0.20***	0.68***	0.75***	-0.77***	-0.76***
	(0.12)	(0.09)	(0.09)	(0.07)	(0.23)	(0.23)	(0.22)	(0.22)
Same Sex Baseline	7.8	4.1	3.9	2.5	58.2	43.0	41.5	35.2
Percent Effect	-3.7	-4.1	-5.4	-8.1	1.2	1.7	-1.9	-2.2
Observations	170,803							
Sample of Second-Born Men								
First-Born Sister	2.37***	1.67***	0.31**	0.16	0.55***	0.14	0.12	-0.01
	(0.24)	(0.23)	(0.14)	(0.12)	(0.21)	(0.23)	(0.20)	(0.19)
Same Sex Baseline	39.0	27.3	9.9	6.6	69.4	53.7	29.8	23.8
Percent Effect	6.1	6.1	3.1	2.4	0.8	0.3	0.4	0.0
Observations	178,306							

All estimates are multiplied by 100 to express effects in percentage points. Standard errors in parentheses, clustered at the year-month of birth level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Sample of second-born children born between 1962 and 1986 with an older biological sibling born within four years apart. Each Panel-Column presents estimates from separate regressions. All models absorb fixed effects for birth municipality, year-month of birth, spacing in months to older sibling, second generation immigrant status, maternal age at birth, paternal age at birth, maternal level-field of education, paternal level-field of education, and age at last educational observation. *Same Sex Baseline* reports the mean outcome for individuals with a same sex sibling. *Percent Effect* reports the estimated effect of sibling gender relative to the baseline.

Table A14

Alternative Measures of Field of Study

	OECD's STEM Definition				Care Fields			
	Field-Specific		College		Field-Specific		College	
	Enroll-ment	Comple-tion	Enroll-ment	Comple-tion	Enroll-ment	Comple-tion	Enroll-ment	Comple-tion
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample of First-Born Women								
Second-Born	-0.70***	-0.75***	-0.42***	-0.36***	0.74***	0.72***	0.57***	0.53***
Brother	(0.25)	(0.21)	(0.11)	(0.10)	(0.23)	(0.22)	(0.21)	(0.19)
Same Sex Baseline	34.8	25.0	6.4	4.4	32.1	26.2	24.6	20.6
Percent Effect	-2.0	-3.0	-6.6	-8.2	2.3	2.7	2.3	2.6
Observations	164,733							
Sample of First-Born Men								
Second-Born	0.50**	0.34	0.28*	0.07	-0.25**	-0.23**	-0.27**	-0.23**
Sister	(0.23)	(0.24)	(0.16)	(0.14)	(0.12)	(0.10)	(0.11)	(0.09)
Same Sex Baseline	67.8	53.5	13.6	9.5	6.7	4.7	6.0	4.3
Percent Effect	0.7	0.6	2.1	0.7	-3.7	-4.9	-4.5	-5.4
Observations	173,340							

All estimates are multiplied by 100 to express effects in percentage points. Standard errors in parentheses, clustered at the year-month of birth level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Main sample (first-born children born 1962–1986 with a second-born biological sibling born within four years apart). Each Panel-Column presents estimates from separate regressions. All models absorb fixed effects for birth municipality, year-month of birth, spacing in months to younger sibling, second generation immigrant status, maternal age at birth, paternal age at birth, maternal level-field of education, paternal level-field of education, and age at last educational observation. *Same Sex Baseline* reports the mean outcome for individuals with a same sex sibling. *Percent Effect* reports the estimated effect of sibling gender relative to the baseline. *OECD's STEM Definition* includes Natural Sciences, Mathematics, Statistics, Information and Communication Technologies, Engineering, Manufacturing, and Construction (thereby including Biology, Manufacturing, and Construction and excluding Economics compared to the main definition). *Care Fields* include Education, Health, and Welfare.