The heterogenous impact of sibling sex composition on adult fertility: A causal effect through sibship size?*

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Abstract

While fertility is positively correlated across generations, causal drivers – if any – of this relationship are poorly understood. The correlation could stem from the fact that parents and children share genetic predispositions and social environment, but it may also reflect a causal effect of sibship size on fertility in adulthood. Access to resources as well as changes in fertility preferences and beliefs about the consequences of childbearing are all possible mediators of a causal effect. Using the sex composition of the two first-born children as an instrumental variable, we estimate the causal effect of sibship size on adult fertility. Estimations are done on high-quality data from Norwegian administrative registers. Our study sample is all first- or second-borns during the 1960s in Norwegian families with at least two children (approximately 126 000 men and 119 000 women). An additional sibling has a positive effect on male fertility, shifting some men into fatherhood. For women, a negative quantum effect emerges, driven by a preference for two rather than three children among women from three-child families. Having an additional sibling may cause women to update their beliefs about the disadvantages of having a large family, leading to a preference for smaller families.

1 Introduction

The number of siblings in one's family of origin significantly affects both childhood conditions and kinship ties in adulthood. As information about the consequences

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of childbearing decisions is imperfect, individuals may draw on experiences in their family of origin when making fertility decisions. An additional sibling may increase both joys and strains of family life: While the parental time and money available to each child is reduced, family stability increases, and parents may develop a taste for larger families which they in turn transmit to their children. Through these and other causal channels, an growing up with an additional sibling may affect the fertility preferences an individual holds in adulthood. The direction of this effect is, however, not a priori obvious.

Numerous studies have shown that the intergenerational correlation in fertility is positive (Murphy 2013). As similarity between parents and children could be driven by genetic predispositions as well as shared social circumstances, the intergenerational correlation in fertility is unlikely to capture the effect of sibship size on fertility in adulthood.

We estimate the causal effect of sibship size in family of origin on fertility behavior in adulthood using an instrumental variable approach. We exploit the fact that a preference for sex mix causes some parents to have a third child if – and only if – the two first born children are of the same sex (Angrist and Evans 1998). Thus, while having two children of the same sex increases the probability of having an additional child, this increase in sibship size is uncorrelated with parents' preferences for number of children.

We study the fertility behavior of Norwegian men and women born in the 1960s, using highly reliable data from Norwegian administrative registers.[1] Using linear probability models, we estimate the effect of having at least two siblings on the final number of children (at age 40), as well as on parity specific measures. Acknowledging that childbearing affects the lives of men and women in fundamentally different ways, we run all models separately by sex to allow for heterogenous effects. We test extensively for direct effects (i.e. effects through channels other than sibship

[1]Applying the same-sex instrument requires that we limit our study sample to individuals with at least one sibling.

size) of sibling sex composition on fertility in adulthood, reassuringly finding none. This strengthens the interpretation that sibship sex composition affects fertility in adulthood through sibship size only.

Our main results are twofold: First, an additional sibling causes some men – who would otherwise have remained childless – to have children in adulthood. Second, an additional sibling causes some women to have two rather than three children. The latter finding stands in contrast to the positive intergenerational correlation in fertility – which is also found in our sample.

To get a better understanding of the mechanisms linking sibship size to fertility decisions in adulthood, we analyze a wide range of potential mediators. Most importantly, we find that an additional sibling significantly reduces mothers' labor supply only if the two first born children are male. Based on previous research on time use, we suggest that mothers of girls are able to work longer hours in paid work because daughters help out more at home than do sons. Girls who grow up in three-child families may be more closely familiar with the strains of larger families. Furthermore, our mediation analysis renders two potential explanations of the negative effects among women unlikely: First, as household income is highest in the girl families, it seems unlikely that the negative effect is mediated by depletion of family income. Second, there is no indication of the results among women being mediated by lower relationship stability.

Among men, the mediation analysis indicates that transmission of "family oriented" across generations may contribute to explain our results: Men from large sibships are less likely to experience parental divorce, and more likely to be married themselves in adulthood. Importantly, sensitivity analysis indicates that sibling sex composition affects the mediators mainly indirectly through sibship size, again strengthening our identifying assumption.

Our results have broader implications for the understanding of fertility contagion. As fertility contagion is mainly found to be positive, it is commonly thought of as an effect multiplier – allowing relatively small changes in the cost of childbearing to be inflated into large fertility responses. Our finding suggests that high fertility in one generation causes high fertility in the next generation *only if* life in large families is not perceived as being too straining. Policies that make life in large families less straining – particularly for women – may thus contribute to maintaining high birth rates in the next generation.

2 Sibling sex composition: IV properties and direct effects

Omitted variable bias could make the intergenerational correlation in fertility, as estimated by OLS regression, quite different from the causal effect of an additional sibling on own fertility outcomes. To estimate the effect of sibship size on fertility in the next generation, we therefore use the sex composition of the two first born children in the family of origin as an instrumental variable for the number of siblings in the family of origin. This is a much used instrument for family size (see for instance Angrist and Evans (1998); Black, Devereux and Salvanes (2010); De Haan (2010)), as it – arguably – satisfies the criteria of a valid instrumental variable: Children's sex composition is correlated with their number of siblings, but uncorrelated with background characteristics of parents (such as fertility preferences) that bear their own influence on children's fertility decisions in adulthood.[2]

In this section, we outline how sibship sex composition may influence fertility outcomes in adulthood, through changes in sibship size or other channels.[3] Our starting point is that the demand for children is influenced by *preferences*, (mone-

[2]If the two first born children are of the same sex, the probability of further childbearing increases, supposedly because of (some) parents' preferences for sex mix (Gini 1951; Ben-Porath and Welch 1976). See Section 4 for a test in our sample. The latter criterion holds because child sex is essentially random and the sex composition of the two first children is therefore uncorrelated with parents' characteristics.

[3]Throughout the paper, we refer to the individuals whose family outcomes we study as index persons. The index persons' sibling(s) and parents constitute their family of origin.

tary and non-monetary) *resources*, and the direct and indirect *costs* of childbearing (Easterlin and Crimmins 1985). Furthermore, as increasingly acknowledged in the demographic literature, information of the consequences of childbearing is not perfect, and the *beliefs* an individual holds about the consequences of childbearing may therefore significantly influence fertility behavior (Bernardi and Klaerner 2014).

Sibling sex composition affects sibship size, which is in turn strongly correlated with fertility in adulthood. Below, we first discuss mechanisms through which sibship size could causally impact fertility in the next generation. Sibship sex composition may conceivably influence individuals' fertility choices in its own right, outside its effect on sibship size. This would yield bias in IV estimates based on sex composition as an instrument for sibship size. At the end of this section, we discuss the nature and likelihood of such direct effects.

2.1 Effects of sibship size on fertility in the next generation

Sibship size is an essential feature of the family environment in which children grow up, affecting various aspects of both children's and parents' lives. Having an additional sibling/child changes material conditions in the household, and may also alter household members' preferences regarding family life. Importantly, it fundamentally affects the relevant experience children have with sibships of a certain size and the beliefs they form about the relative bliss and strain of having a large family. For all these reasons, we expect sibship size to impact individuals' own fertility decisions in adulthood.

In households with larger sibships, the level of parental resources available to each child is lower: Even if the total level of family income were not affected by sibship size, both income and parents' time is relatively more scarce as there are more mouths to be fed and ears to be read for. Moreover, family income will often decrease with sibship size, as mothers shift time away from labor market activities to unpaid work at home. The decrease may be substantial, and is not necessarily fully compensated by an increase in fathers' earnings (for the US, Angrist and Evans (1998) estimate a net reduction in family income of 5.3% from having more than two children). Hence, growing up with more siblings may mean lower "investment" in the child throughout its childhood and may thus cause lower levels of education and human capital (Becker 1991).[4] At lower levels of human capital, the cost of taking time off work to care for children is relatively smaller. A decrease in human capital may therefore lead to higher fertility, at least for women (see e.g. Kravdal and Rindfuss (2008) for Norway).

Furthermore, having more siblings to share with, and mothers with (on average) lower life time earnings, individuals from larger sibships receive relatively less economic transfers from their parents in adulthood (Goodsell et al. 2013). Access to less economic resources is expected to translate into lower fertility through a negative income effect, all else equal. Research on whether parents' economic resources affect fertility decisions is scarce, however. Waynforth (2011) finds no significant correlation between fertility behavior and economic support from (grand)parents.

Aside from its effect on material conditions, sibship size may expectedly influence individuals' fertility preferences. Fertility intentions are consistently found to be *adaptive* – that is, adjusted in accordance with fertility behavior (Hayford 2009). The birth of an additional child may therefore cause parents to prefer a large family more strongly than before, a preference that in turn may be transmitted to their children.[5] The theory of *imitation* suggests that individuals use their parents' fertility behavior as a blueprint for own family formation (Starrels and Holm 2000). Thus, even if parents' fertility preferences remain unchanged by the birth of a third child, a second sibling would increase the preferred number of children in the next generation.

[4]This is consistent with the negative correlation between sibship size and average education level (see e.g. Blake (1989); Downey (1995); Park (2008)). However, causal studies of this trade-off fail to identify a negative effect of sibship size on children's educational level and IQ (Black, Devereux and Salvanes (2005, 2010); De Haan (2010).

[5]Such preference transmission is considered an important mechanism in the literature on intergenerational transmission of fertility (Starrels and Holm 2000; Kolk 2014)

While (hopefully) bringing joy, an extra child is a time- and effort-consuming addition to the family, possibly adding strain to the lives of adults as well as children. On average, an additional younger sibling increases the time children spend on housework, more so for girls than for boys (Evertsson 2006). Gager, Cooney and Call (1999) find that among teenagers from large sibships, girls cut back on own spare time activities to help care for their younger siblings, while boys do not. Furthermore, having three children relative to two thwarts women's careers much more than men's (Cools 2013; Hardoy and Schøne 2008). Growing up in a three-child family may thus give women first hand experience of the challenges of pursuing a career while giving three children a good upbringing. Potentially, such first hand experience may make women reluctant to have larger families themselves.

The effect of sibship size on fertility in adulthood could thus be either positive or negative. The theories of adaptive preferences and of imitation predict a positive effect of sibship size on fertility in the next generation for both men and women. Taken to the extreme, the theory of imitation suggests that index persons with a second sibling will all prefer to have three children themselves. In theory, at least, a positive effect could also result from lower human capital investment due to the extra sibling, which reduces the substitution cost of childbearing.

A negative effect, on the other hand, could reflect an income effect due to the the relative depletion of parental resources in larger sibships, for both men and women. In addition, large families have some disadvantages for the lives of mothers and daughters that may not be obvious to women who grow up with one sibling only, potentially resulting in a negative causal effect of sibship size on own fertility in adulthood especially for women.

Most notably, the effect of sibship size on fertility in adulthood is likely to differ for men and women. In particular, since women's careers are the most affected by childbearing, and since girls are more likely to be involved in caring for the younger siblings, it is not unlikely that women's fertility in adulthood would be less positively linked to their parents' number of children, than men's fertility. To allow for heterogeneity in the causal effect of sibship size on fertility in adulthood, all the estimations in this paper are done separately by sex.

2.2 Direct effects of sibling sex

Sibship sex composition has been widely applied as an instrumental variable for sibship size in previous research, but it has to our knowledge not yet been applied to the study of the intergenerational transmission of fertility. Moreover, once the sample is split by index person's sex, we can no longer control for the sex of the other sibling (as this gives perfect collinearity with the instrumental variable). Regarding the estimation of heterogeneous causal effects, we therefore need to consider potential direct effects of sibling sex individually.

First, sibship sex may affect the flow of help and support between members of the family, potentially affecting the time cost of childbearing. Emery (2013) and Goodsell et al. (2013) find that practical help from (grand)parents decreases in number of sisters and not in number of brothers, indicating that a sister provides more competition over grandparental resources than a brother does. There is however no empirical evidence that help from maternal grandparents increases fertility more than help from paternal grandparents (Aassve, Meroni and Pronzato 2012; Tanskanen et al. 2014). Spitze and Trent (2006) show that women report to help their siblings significantly more with child care than men do.

Second, the sex of the second sibling might affect fertility preferences. In a large qualitative study of Italian women's fertility, Bernardi (2003) find that having a sister increases women's fertility preferences more than having a brother. Last, siblings may influence each other's fertility decisions, possibly in a way depending sibling sex composition. Empirical studies of how sibship sex composition is correlated with fertility transmission among siblings are rare and they yield mixed results. Importantly, they do not consider the role of sibship size in this inter-sibling exchange.[6]

As the above discussion makes clear, potential bias in our IV estimates due to direct effects of sibling sex, can neither be ruled out nor perfectly assessed with respect to its size or direction on theoretical grounds. Having a sister relative to a brother may both increase fertility through increased access to practical help from the sibling and by social contagion, but it may also reduce fertility through depletion of grandparental resources. We can, however, test empirically whether the sex of a different sibling has any impact on fertility (or the other outcomes considered).[7] Our findings in this matter are clear: We find no evidence of the third sibling's sex affecting any of the outcomes considered in this paper.

3 Data and empirical approach

3.1 Study sample

Our point of departure is data from Norwegian administrative registers on all Norwegian residents. Personal identifiers link individuals to their parents and children. For registering to be complete, we restrict mothers to be born no earlier than 1935.[8] The need for reliable data on both family background and on own completed fertility makes individuals born during the 1960's particularly suited, hence we focus on the

[6]The findings range from no influence (Kotte and Ludwig (2011) for Germany), to a positive influence from female siblings only (Kuziemko (2006) for the US), to a slightly more positive influence from male than from female siblings (Lyngstad and Prskawetz (2010) for Norway). For instance, Lyngstad & Prskawetz condition on a sibship size of two, meaning that parents with a preference for sex mix are more strongly selected out in the sample of same sex siblings.

[7]This testing can be done in the subsample of families who have at least three children, and where the first two are of opposite sex. The sex of the third child in this subsample does not influence sibship size, and can therefore be used to study pure sibling sex effects.

[8]Information on birth year, gender, and an identifier linking the individual to information in other registers, exists for every person who has resided (legally) in Norway since 1968. Complete registering of children started in 1970. At the same time, children younger than 17 were registered to their mothers (and to some extent their fathers). Data on number of children born to an individual are therefore complete for women born around 1935 (if they started having children no sooner than at 18, their oldest child would be maximum 17 in 1970), and for men born somewhere between 1935 and 1952 (insofar as they are publicly registered as fathers). Thanks to Øystein Kravdal for this information.

Table 1: Family background variables by sex composition

	Same sex		Different sex		Difference	
	Mean	SD	Mean	SD	Est.	SE
Distance two first children (years)	2.45	(1.31)	2.46	(1.33)	-0.01	(0.01)
Mother's						
- year of birth	1941.47	(3.45)	1941.48	(3.47)	-0.01	(0.02)
- age at first birth	22.13	(2.81)	22.16	(2.84)	-0.03*	(0.02)
Father's						
- year of birth	1937.99	(4.95)	1938.02	(4.96)	-0.04	(0.03)
- age at first birth	25.62	(4.38)	25.62	(4.39)	-0.00	(0.03)
N	53431		53814		107245	

Note: The samples are all couples with at least two children, where the two first children are both born in Norway in the period 1960-1969 and are registered with the same mother and father. For the means, standard deviations are reported in parentheses, for the estimated differences, standard errors are in parentheses. * $p < 0.10$,** $p < 0.05$, *** $p < 0.01$.

sample of individuals born between 1960 and 1969.

As the sex composition instrumental variable is defined only for families with at least two children, our sample is limited to these families, i.e., whose first two children were both born between 1960 and 1969. We further exclude families in which the first two children do not share both parents, or where either parent is unknown to the registers. The study sample does not include individuals who are themselves twins, but they may have twin siblings.

3.2 Family background characteristics

Since the individuals under study are born during the 1960s, background characteristics that are exogenous to their sibling sex composition must be observed further back than most of the important Norwegian registers go. Parents' income could be observed from 1967 onwards, and their education from 1970 onwards, both of which are too late for our purpose. The only background variables for our study sample that are realized prior to the instrument, are parents' year of birth, their age at first birth and the distance (in years) between the births of the first two children.

The means of these variables are reported in Table 1. We have split the sample into families with two children of the same sex (first column) and of different sex

Table 2: Mean values in outcome variables, by index person's sex

	Men		Women	
	Mean	SD	Mean	SD
N. children at 40	1.65	(1.22)	1.99	(1.14)
Has children at 40	0.75	(0.43)	0.86	(0.34)
Has >1 child at 40	0.59	(0.49)	0.72	(0.45)
Has >2 children at 40	0.24	(0.43)	0.32	(0.46)
Has >3 children at 40	0.05	(0.22)	0.07	(0.25)
N	111151		104719	

Note: The samples consist of all first- and second born men and women born in Norway between 1960 and 1969 in families with at least two children, where the two first children are registered with the same mother and father. Standard deviations in parentheses.

(second column). The last column in Table 1 reports simple t-tests of whether the background characteristics vary with the sex composition of the first children.

When we include background variables as controls in the estimations of how fertility in adulthood is affected, they enter as a set of dummy variables capturing the distance in years between the birth of the first and the second sibling (censored at six years), and dummies for parents' age at first birth (by age brackets of five years each). The full set of dummy variables to be used as controls throughout the paper is given in Appendix Table A.2, in addition to t-tests of the difference by instrument status, for all the different sample cohorts used in this paper. Though all the estimated differences according to same sex sibship are small, several of them are statistically significant. As can be seen in Table A.2, however, there is no consistent pattern across sample birth cohorts.

3.3 Fertility outcome variables

The main outcome variable considered in this paper is the total number of children registered to the individual at the age of forty. We also evaluate parity specific outcomes by considering separately the probability of having more than 0, 1, 2 and 3 children at this age. Descriptive statistics for these outcomes are given separately for men and women in Table 2.

As we are mainly interested in the effect on fertility at the end of the individual's reproductive career (*quantum effects*), fourty is arguably on the young side, especially for men. In Appendix A, we therefore present estimates from separate regressions for each age from 20 to well past 40 (with slight abuse of demographic parlance, we think of these as *tempo effects*).[9] However, as we have data on births up to 2013, the whole sample can only be followed until they are 42 years old, from which point on we lose 10% of the original sample with each yearly increment in age.

3.4 Additional outcome variables

In the investigation into mechanisms, analyzed in Section 5, we study three sets of additional outcome variables. First, we study potential mediators of fertility effects measured in the index person's childhood, such as parents' income and marital stability. Second, we study how sibship sex composition and size shapes the transition to adulthood, by looking at earnings and educational outcomes in their late teens, as well as early childbearing. Finally, we study the effect on partnership behavior in adulthood, potentially mixed up with the effect on fertility, such as marital stability and assortative mating.

Education data come from Statistics Norway's education registers, which record all changes (and their dates) in individuals' highest educational attainment from 1970 onwards. Information on yearly personal income (consisting of wages, pensions and entrepreneurial income) goes back to 1967 and covers the population residing in Norway each year. The demographic registers contain data on marital status from 1992 onwards, that is, from when the youngest individuals in our sample are aged 23 and the oldest 32 years. The observation of parents' marital status when the second child is aged 28 therefore serves as a proxy for their marital status when the children still live at home (underreporting marriages that were still intact in earlier

[9]All outcomes are defined by the number of children born to the individual *at the end of the year before* the individual turns the age in question.

years). The descriptive statistics for these outcomes are given in Table A.1 in the Appendix.

3.5 Empirical strategy

The aim of this study is twofold. First, we estimate the effect of sibship sex composition on fertility in adulthood, using OLS regression (*reduced form estimates* in the IV terminology). These estimates have a causal interpretation under the uncontroversial assumption that child sex is random.

Second, utilizing that sibship sex composition significantly affects sibship size, we use sibship sex composition as an instrumental variable for sibship size. This allows us to estimate the effect of sibship size on fertility in the next generation, holding variation in (initial) fertility preferences between parents of two and three children constant. IV estimation yields unbiased causal estimates under the assumption that sibship sex composition affects fertility in the next generation through sibship size only (see Section 2.2 for a discussion of this assumption).

IV estimation is done in two steps, using *two stage least squares* (2SLS) regression. We first estimate the effect of sibship sex composition on sibship size, giving the *first stage estimates.* IV estimates are then obtained by regressing the part of the variation in the sibship size tied to the sex composition on the index persons' fertility in adulthood.

The IV estimate captures the average treatment effect among those moved by the instrument (Imbens and Angrist 1994). In our case, the IV estimate is the *local average treatment effect* (LATE) of having a third child for those parents who will have a third child if and only if their two first children are of the same sex.

Table 3

	First stage		*Red. form*		*IV estimate*		*First stage*		*Dir. Effects*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
MEN	>1 sibling		N. of children		N. of children		>2 siblings		N. of children	
	OLS	OLS	OLS	OLS	2SLS	2SLS	OLS	OLS	OLS	OLS
Same sex	0.059***	0.057***	0.019**	0.019**			-0.001	0.000	-0.004	-0.004
	(0.003)	(0.003)	(0.007)	(0.007)			(0.005)	(0.005)	(0.014)	(0.014)
>1 sibling					0.321**	0.325**				
					(0.125)	(0.128)				
Birth year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth order FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
R2	0.018	0.106	0.002	0.006	.	0.002	0.015	0.058	0.002	0.004
N	110226	110225	110226	110225	110226	110225	32274	32273	32274	32273
WOMEN	>1 sibling		N. of children		N. of children		>2 siblings		N. of children	
	OLS		OLS		2SLS		OLS		OLS	
Same sex	0.063***	0.061***	-0.012*	-0.014*			0.000	-0.001	0.012	0.012
	(0.003)	(0.003)	(0.007)	(0.007)			(0.005)	(0.005)	(0.013)	(0.013)
>1 sibling					-0.195*	-0.220*				
					(0.114)	(0.116)				
Birth year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth order FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
R2	0.019	0.108	0.002	0.007	.	.	0.015	0.059	0.001	0.003
N	103761	103760	103761	103760	103761	103760	32275	32274	32275	32274

Note: The sample is individuals in Norwegian families with at least two children, where the two first children are registered with the same mother and father and are born between 1960 and 1969.
* $p < 0.10$,** $p < 0.05$, *** $p < 0.01$.

4 Effects on fertility in adulthood

The discussion in Section 2.2 shows that although sibling sex composition is a much used instrumental variable for sibship size, the possibility of direct effects from having a sibling of the same sex cannot be a priori dismissed. This possibility may be of particular concern when the outcome considered is fertility in the next generation. In the following, we therefore present estimates both of sibling sex composition directly (*intention to treat*-estimates or *reduced form*-estimates) and the IV estimates where sex composition is used as an instrumental variable for sibship size.

The main results of this paper are presented in Table 3. Columns (1) and (2) give first stage estimates, columns (3) and (4) the reduced form estimates, and columns

(5) and (6) the IV estimates. The upper panel gives estimation results for men, the lower for women. In all the specifications estimated in Table 3, we include a set of dummy variables indicating the exact year in which the index person is born in addition to a dummy variable indicating whether he or she is first or second born. In the even-numbered columns we have also included a set of exogenous control variables: Parents' year of birth, their age at first birth and the distance in age between the first two siblings.[10]

Columns (1) and (2) in Table 3 give the OLS estimates of how being in a same sex sibship affects the likelihood that individuals in our sample will have an additional sibling. In the IV-framework, these are the first stage estimates. The estimates are slightly larger for women than for men, but they are all very close to a 6 percentage point increase in the likelihood of having an extra sibling if the first two children are of the same sex. As first stage estimates, these are comparable in size to other applications of this instrument. With t-statistics above 20, they also satisfy the criterion of instrument relevance.

Columns (3) and (4) give the OLS estimates of how being in a same sex sibship affects individuals' own number of children when they are 40 years old. Having a brother causes the men in our sample to have .019 more children on average (the estimate is significant at the 5% level). On the other hand, having a sister causes the women in our sample to have .014 *fewer* children on average (this estimate is significant at the 10% level).

For both men and women, the estimates in columns (3) and (4) show a negative effect on own fertility of having a sister rather than a brother. The causal character of these estimates is uncontroversial, the question is to what extent the causal effect of having a sister is channeled through sibship size. The estimates in columns (1) and (2) show that having a sibling of the same sex gives a 6 percentage point higher probability of having yet another, younger, sibling. This effect on sibship size is

[10]The outcome and the control variables are described in Section 3 and in Appendix Table A.2.

likely to play a major role in the estimated effect of same sex sibship on individuals' own fertility (columns (3) and (4)). Under the assumption that it is in fact the *only* causal channel from sex mix to fertility in adulthood (i.e., the *exclusion restriction* for instrument validity), the 2SLS estimates in columns (5) and (6) are unbiased estimates of the causal effect of sibship size on individuals' total number of children at age 40. According to these estimates, having an additional sibling as a child causes men to have .3 more children and women to have .2 fewer children on average in adulthood.

The different directions of the effects by the index person's sex run counter to what might be expected based on the consistently positive intergenerational correlation in fertility between parents and their children of either sex. They are, however, consistent with the argument about belief formation put in Section 2.1: We expect that girls to a larger extent than boys learn of the strains of childrearing when having an additional sibling – and then potentially limit their family size in adulthood. In absence of this negative belief formation, men seem to behave in a way more consistent with explanations extensively employed in the literature on intergenerational transmission, such as transmission of adaptive preferences or imitation.

In order to assess the potential bias in the IV estimates in columns (5) and (6), we study how sibling sex mix affects fertility decisions in adulthood in the case where it does not change sibship size (i.e., in the case where there is no first stage). Among the families in our sample who had two first children of opposite sex and then nevertheless moved on to have a third child, the sex of this third child does not influence the decision to have a fourth child. This sample is therefore particularly suited to investigate the direct effect of sex composition, rid of any effect going through sibship size.

Columns (7) and (8) in Table 3 show how a second sibling (i.e., the family's third born) being of the same sex as the index person affects parents' further childbearing in the restricted sample. For both men and women, this effect is quite precisely

Table 4

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MEN	>0 children		>1 child		>2 children		>3 children	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Same sex	0.005*		0.006**		0.007***		0.001	
	(0.003)		(0.003)		(0.003)		(0.001)	
>1 sibling		0.080*		0.103**		0.123***		0.026
		(0.045)		(0.052)		(0.045)		(0.023)
Birth year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth order FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R2	0.006	.	0.004	.	0.004	0.002	0.003	0.004
N	110225	110225	110225	110225	110225	110225	110225	110225
WOMEN	>0 children		>1 child		>2 children		>3 children	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Same sex	0.001		-0.002		-0.009***		-0.002	
	(0.002)		(0.003)		(0.003)		(0.002)	
>1 sibling		0.024		-0.038		-0.148***		-0.039
		(0.034)		(0.045)		(0.048)		(0.026)
Birth year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth order FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R2	0.006	0.006	0.003	.	0.006	.	0.003	.
N	103760	103760	103760	103760	103760	103760	103760	103760

Note: The sample is individuals in Norwegian families with at least two children, where the two first children are registered with the same mother and father and are born between 1960 and 1969. * $p < 0.10$,** $p < 0.05$, *** $p < 0.01$.

estimated to be zero; the sex of the third child does not influence parents' propensity to have a fourth child in this sample. In columns (9) and (10), we estimate whether having a same sex second sibling impacts fertility at age 40. The estimates show no significant effect on having a sibling of the same sex on individuals' own fertility in adulthood, for neither men nor women. The point estimates go in the opposite direction of the ones in columns (3) and (4). With the appropriate disclaimer in mind, we find it unlikely that the 2SLS estimates in columns (5) and (6) are severely biased. If anything, the bias indicated by the estimates in columns (5) and (6) would push the 2SLS estimates towards zero. That being said, we continue presenting both the reduced form and the IV estimates in the following analyses.

4.1 Parity-specific effects

The estimates presented in Table 3 show that men's total number of children in adulthood is positively affected by brotherhood/sibship size, whereas the number of children women choose to have in adulthood is negatively affected by sisterhood/sibship size. In order to know which fertility margins are affected, we evaluate the effects of same sex sibship and sibship size on the likelihood of having more than 0, 1, 2 and 3 children. If the negative effects among women are indeed mediated by belief formation, we expect women from larger sibships to avoid forming large families themselves – leading to more marked negative effects on higher parities. Among men, parity specific results can help evaluate the explanatory power of two of the suggested causal mechanisms: The theory of imitation suggests that men who grow up in three-child families prefer to have three children themselves in adulthood, thus predicting particularly strong effects at parity three. If, on the other hand, the results are driven by transmission of a more general family orientedness, we would expect to observe effects on all parities.

The reduced form (odd-numbered columns) and IV estimates (even-numbered columns) are given in Table 4. For women, the only margin affected is the likelihood of having three or more children. Again interpreted as the effect of sibship size, the additional sibling makes women 14.8 percentage points less likely on average to have a third child. This supports the notion that women who grow up in large sibships are reluctant to form large families themselves in adulthood.

For men, fertility at all margins except the highest (the likelihood of having more than three children) is affected. The effects are not significantly different from each other, but the greatest effect regards the likelihood of having more than two children. Interpreted as the effect of sibship size, men are on average 12.4 percentage points more likely to be fathers of at least three children if they have a second sibling. There are thus some indications that men do imitate the family behavior from their family of origin, but as the parity specific results do not differ significantly, evidence is not firm. The presence of effects on parites other than the third indicates that transmission of a “general family oriented behavior” contributes to the effects observed among men.

We have also estimated direct effects for each parity, as in Table 3, and reassuringly, there is no evidence of direct effects at any parity at the age of 40. These results are available from the authors upon request.

5 Understanding the heterogeneous effects on fertility in adulthood

The findings presented in the previous section indicate that sibship size have the opposite effect on men’s and women’s fertility in adulthood, insofar as we believe in the validity of same sex sibship as an instrumental variable for sibship size. Most notably, given the consistently positive correlation in fertility between parents and children, there is a negative effect of sibship size on women’ fertility, it is stronger among second born women, and it is entirely due to a lower propensity to have a third child among women who experienced having a second sibling. The findings indicate that additional siblings are perceived less favorably by females – either from the perspective of the child or later, as mothers – making them less prone to have a large family themselves.

In order to better understand the results presented above, we estimate the effect also on several other outcomes (as described in Section 3.4): Potential mediators in the family environment during the index person’s childhood and youth, and on outcomes related to family formation.

As shown in the following, our findings regarding these other outcomes support the idea that having an extra sibling may constitute a more straining experience for girls than for boys: Mothers’ income upon the birth of a third child falls much more in the men’s (boys’) sample than in the women’s (girls’) sample, and parents’ marital stability is more positively affected by the increase in family size in the men's/boys' sample. We also note that an additional sibling seems to speed up the transition to adulthood, as it increases youths' earned income and the chance of early childbearing. Last, we find that an increased propensity to marry might to some extent explain the positive effect on men's fertility, but we do not find corresponding evidence of marital instability to explain the negative effect of sibship size on women's fertility.

5.1 Childhood conditions

Sibship size is likely to affect especially the material conditions under which individuals grow up.[11] In Table 5, we present both the reduced form and the IV estimates of the effect of sibling sex mix and sibship size on parents' income from work and on parents' marital stability. Columns (1) and (4) give the reduced form estimates of the effect of same sex sibship on the outcome indicated on the row header, for men and women, respectively. The difference between these estimates (estimated in a pooled model) is given in column (7). Columns (2) and (5) give the corresponding IV estimates of the effect of having more than one sibling (instrumented by same sex sibship) on this outcome. For brevity, we mainly comment on the IV estimates rather than the reduced form, and hence effects will be described as resulting from sibship size. Columns (3) and (6) give the estimated direct effect of same sex sibship on the outcome in question in the sample where sibship sex mix does not affect sibship size, as described in Section 4 – i.e., the sample of families with two first children of mixed sex who still had a third child.

[11] Bütikofer (2011) tests whether child costs depend on sibling sex composition in a wide range of countries, and finds no evidence of economies of scale in consumption for families with same sex children in richer countries.

Table 5: The effect of sibship size and sex mix on childhood circumstances

	Men			Women			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Outcome:	Red.form	IV est.	Dir.Eff.	Red.form	IV est.	Dir.Eff.	Diff.
Father's income 1-5	-0.002	-0.030	-0.003	-0.002	-0.038	0.003	0.000
	(0.002)	(0.029)	(0.003)	(0.002)	(0.028)	(0.003)	(0.002)
Father's income 6-10	0.000	0.009	-0.000	-0.002	-0.036	-0.000	0.003
	(0.002)	(0.039)	(0.004)	(0.002)	(0.038)	(0.004)	(0.003)
Father's income 11-15	-0.003	-0.049	0.001	-0.001	-0.024	-0.002	-0.001
	(0.002)	(0.041)	(0.004)	(0.002)	(0.039)	(0.004)	(0.003)
Mother's income 1-5	0.004	0.065	-0.007	0.005	0.073	0.007	-0.001
	(0.004)	(0.070)	(0.008)	(0.004)	(0.066)	(0.008)	(0.006)
Mother's income 6-10	-0.008***	-0.136***	-0.003	-0.003	-0.053	0.003	-0.005
	(0.003)	(0.052)	(0.006)	(0.003)	(0.049)	(0.006)	(0.005)
Mother's income 11-15	-0.027***	-0.475***	-0.006	-0.006*	-0.094*	0.005	-0.021***
	(0.003)	(0.057)	(0.006)	(0.003)	(0.054)	(0.006)	(0.005)
Parents married at 28	0.008***	0.122***	0.002	0.003	0.044	-0.001	
	(0.003)	(0.047)	(0.005)	(0.003)	(0.046)	(0.005)	

Note: The samples are mothers and fathers in Norwegian families with at least two children, where the two first children are registered with the same mother and father and are born between 1960 and 1969. * $p < 0.10$,** $p < 0.05$, *** $p < 0.01$.

Parents' income

If the addition to the family reduces parents' total labor supply, this will result in lower family income – and in more time spent by at least one parent at home. The first six rows of Table 5 give the estimates of how parents' income was affected by same sex sibship and additional children during the childhood years of the individuals – the index persons – in our sample. Income is measured in standard deviations, and then averages are taken over the years when the second born child is aged 1-5, 6-10 and 11-15 years.

Fathers' income is not moved by sibship size in our sample. Mother's income, on the other hand, is lowered in the years when the second child is aged 6-10 years and 11-15 years, but not during the first 1-5 years. This may reflect that mothers of two and three children alike reduce their working hours to take care of the second child in its early years (under the age of 5), while those who have a third child are relatively more likely to remain at home after this age.[12]

[12]The estimates are done by age of the second child, since this measure is defined for the whole sample. The third child, if born, will on average be about three years younger than the second child.

There is a substantial difference in the point estimates for the effect of another child on mothers' income in the men's and the women's samples. When the second child is 6-10 years old (and a third child on average 3-7 years old), the effect in the men's sample is a reduction in mothers' income of 14% of a standard deviation, while the reduction is 5.3% of a standard deviation – not statistically significantly different from zero – in the women's sample. Later, when the second child is aged 11-15, the reduction in mother's income is about half a standard deviation in the men's sample, and only one tenth of a standard deviation in the women's sample.

As the estimates in columns (3) and (6) show no evidence of a direct effect of sex mix on mothers earnings, the explanation seems not to lie with a violation of instrument validity. Rather, it seems likely that the effect of having a third child on mothers' labor supply is affected by whether they have daughters to help out with caring for the younger sibling. When the second child is 11-15 years old, the oldest child would be about 13-18 years old, and both children would be expected to help out at home – especially if they are girls.[13] Thus, mothers of girls may indeed choose to reduce hours worked less than mothers of boys upon the birth of a third child exactly because a "team" of two girls at home is of more help than a "team" of two boys. Compared to boys who have a second sibling, girls who have a second sibling would either have to help out more at home, and/or make do with less parental time.[14] This supports the explanation that the negative effects on fertility among women are being (partly) mediated by belief formation.

If depletion of family income were driving the negative effects found on women's fertility through the income effect, as suggested in Section 2.1, we would expect to

[13]Data from Norwegian time use surveys indicate that as teenagers, the girls in our index cohorts contribute substantially more to household work than do boys. The time use data that come closest to covering our cohorts includes men and women born 1956-1964, and are collected in 1980, when these men and women are aged 16-24 years old. While male respondents on average spends 1,35 hours daily on housework, the time spent on housework is about 50% higher among female respondents (2,41 hours)`https://www.ssb.no/a/kortnavn/tidsbruk/tab-2002-05-13-03.html`)

[14]Gauthier, Smeding and Furstenberg (2004) find that mothers increased working hours hardly reduce time spent on active child rearing, thus strengthening explanations linked to children's participation in housework.

find a relatively stronger negative effect of sibship size on mothers' income in the women's sample. As the results reveal the opposite pattern, lower family income seems an unlikely mediator of the negative effects found among women. Rather, the depletion of another resource – mothers' time – may seem to have a stronger impact in the intergenerational transmission.

Parents' marital stability

The last row in Table 5 presents estimates of the effect of sibship size on the marital stability of the parents in the family of origin.[15] For both men and women, the estimated effect on their parents' likelihood of remaining married is positive. The estimate is however only statistically significant in the men's sample. Again we find no evidence of direct effects of sex mix in columns (3) and (6).[16] Children from intact homes may have a more positive experience of family life in their childhood, leading to increased fertility in the next generation (Axinn and Thornton 1996). However, neither Kreyenfeld (2004) nor Rijken and Liefbroer (2009) find any correlation between parent's divorce and fertility behavior in adulthood (though the latter measures divorce net of conflict level). An increasing propensity to form (marital) unions may thus contribute to the positive effects estimated among men.

5.2 Teenage and early adulthood outcomes

A much hypothesized effect of increased sibship size is that parents will invest less in each child, and that as a result, children from larger sibships will have lower educational attainment. As shown in the first line of Table 6, we find no significant effect of sibship size (or sex mix) on the likelihood of completing high school by the age of 19.[17] A quality-quantity tradeoff could be expected to contribute to higher

[15]Parents' marital status can only be observed from 1992 onwards, hence the observation at age 28 of the second child is only a proxy for marital status in the childhood home (see Section 3.4).

[16]In the European context, no consistent relationship between child sex and divorce risk is found (Diekmann and Schmidheiny 2004).

[17]The finding that education of Norwegian children is not affected by sibship size is in line with the finding in Black, Devereux and Salvanes (2005).

Table 6: The effect of sibship size and sex mix on outcomes in early adulthood

	Men			Women			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Outcome:	Red.form	IV est.	Dir.Eff.	Red.form	IV est.	Dir.Eff.	Diff.
Index person's sec. educ. at 19	0.004	0.061	-0.004	-0.001	-0.015	0.007	0.005
	(0.003)	(0.048)	(0.005)	(0.003)	(0.049)	(0.005)	(0.004)
Index person's income 18-20	0.005	0.091	0.014	0.015***	0.236***	-0.009	-0.009
	(0.006)	(0.103)	(0.011)	(0.004)	(0.074)	(0.008)	(0.008)
Index person's income at 15	0.015**	0.248**	0.012	0.007	0.094	0.008	0.008
	(0.008)	(0.126)	(0.015)	(0.006)	(0.087)	(0.010)	(0.010)
Index person's income at 16	0.029***	0.530***	0.003	0.016***	0.261***	0.008	0.014
	(0.009)	(0.173)	(0.018)	(0.006)	(0.099)	(0.011)	(0.012)
Index person's income at 17	0.031***	0.523***	-0.011	0.018**	0.284**	0.010	0.016
	(0.011)	(0.195)	(0.022)	(0.008)	(0.128)	(0.015)	(0.015)
Index person's has child at 15	0.000	0.000	-0.000	0.000	0.000	-0.000	0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Index person's has child at 16	0.000	0.000	-0.000	0.000	0.001	-0.000	-0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)
Index person's has child at 17	0.000**	0.005**	-0.000	0.001	0.008	0.000	-0.000
	(0.000)	(0.002)	(0.000)	(0.000)	(0.005)	(0.001)	(0.000)
Index person's has child at 18	0.001***	0.011***	-0.000	0.001	0.018	-0.000	-0.001
	(0.000)	(0.004)	(0.000)	(0.001)	(0.011)	(0.001)	(0.001)
Index person's has child at 19	0.001**	0.014**	-0.000	0.003**	0.044**	0.004*	-0.002*
	(0.000)	(0.007)	(0.001)	(0.001)	(0.019)	(0.002)	(0.001)
Index person's has child at 20	0.002**	0.028**	-0.000	0.003**	0.057**	0.002	-0.002
	(0.001)	(0.012)	(0.001)	(0.002)	(0.026)	(0.003)	(0.002)
Index person's has child at 21	0.003**	0.045**	-0.001	0.003	0.054	0.006	-0.001
	(0.001)	(0.018)	(0.002)	(0.002)	(0.033)	(0.004)	(0.002)
Index person's has child at 22	0.005***	0.087***	0.002	0.003	0.044	0.006	0.002
	(0.001)	(0.024)	(0.003)	(0.002)	(0.038)	(0.004)	(0.003)

Note: The samples are men and women born in Norwegian families with at least two children, where the two first children are registered with the same mother and father and are born between 1960 and 1969. * $p < 0.10$,** $p < 0.05$, *** $p < 0.01$.

fertility among women (due to lower substitution costs) and lower fertility among men (through the income effect). The absence of evidence for a quality-quantity tradeoff falls well in line with the findings in Section 4, which reveal fertility effects going in the opposite direction.

There is a strong positive effect on the index person's earned income. As teenagers from larger sibships have access to relatively less economic resources, it is unsurprising that they would be willing to allocate more of their spare time (considering that education is not affected) to part time jobs.

Finally, the number of siblings could possibly have effects on teenage fertility. All else equal, an earlier onset of childbearing will lead to higher fertility in adulthood.

Table 7: The effect of sibship size and sex mix on outcomes related to family formation

	Men			Women			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Outcome:	Red.form	IV est.	Dir.Eff.	Red.form	IV est.	Dir.Eff.	Diff.
Married at 40	0.009***	0.152***	0.003	0.004	0.070	-0.003	0.004
	(0.003)	(0.053)	(0.006)	(0.003)	(0.051)	(0.006)	(0.004)
Divorced at 40	0.001	0.022	-0.003	-0.005**	-0.084**	0.000	0.006**
	(0.002)	(0.033)	(0.004)	(0.002)	(0.037)	(0.004)	(0.003)

Note: The samples are men and women born in Norwegian families with at least two children, where the two first children are registered with the same mother and father and are born between 1960 and 1969. * $p < 0.10$,** $p < 0.05$, *** $p < 0.01$.

The positive effects found among men in Table 6 are thus as expected, while the tendency of a positive effect on teenage fertility among women is perhaps more surprising.[18]

5.3 Outcomes related to family formation

In Table 7, we present the reduced form estimates, the IV estimates, and the direct effects estimates (as in Table 5 and 6) for outcomes related to the partnering behavior of the index person measured later in adulthood: The (separate) probabilities of being married and divorced at the age of 40, as well as assortative mating (conditional on having at least one child). A description of these outcomes is given in Section 3. Naturally, these outcomes are as much a likely result of as a cause for fertility behavior, but they may nevertheless shed light on the role partnership behavior plays in generating our results.

Table 7 show the estimated effect on the index person's likelihood of being married and divorced at the age of 40, respectively. For men, an additional younger sibling increases the likelihood of being married at age 40 by 15 percentage points, and it does not affect the likelihood of divorce, indicating that growing up in a relatively large sibship increases men's "family orientedness" more generally – shifting some men who would otherwise have remain unmarried into marrying and into having

[18]However, the observation that the same determinant can affect fertility tempo and quantum differently is not novel – consider e.g. the relatively early childbearing but comparatively low number of children among men with lower education Kravdal and Rindfuss (2008).

children.

For women, there is no significant effect on the likelihood of being married at age 40 (though the point estimates are also positive). As marriage is strongly linked to the *transition* to parenthood – not affected in the female sample – this is not very surprising. Interestingly, Table 7 shows a statistically significant negative effect of sibship size on the likelihood of being divorced among women, indicating that the negative effects of sibship size on women's fertility is not driven by union instability.

Experiences in the family of origin may affect preferences in the partner market, which may in turn influence fertility. Particularly, if men who have an additional sibling tend to find partners from large families (who share the preference for large families), this may contribute to the positive effects in the male sample.[19] We have therefore investigated whether sibship size and sex mix affect the likelihood of having a partner from a particular sibship size or sex mix, or with a specific birth rank.

We find no evidence that assortative mating is affected by sibship size and sex mix for our index persons, neither in terms of partners' sibship size, sex mix or birth rank. The estimates are reported in Table 8. As close to every second first birth in Norway currently is to cohabiting parents, we look at assortative mating with respect to the parent of the index person's first child.[20] This outcome is obviously endogenous with respect to ever having a child, which is clearly affected by sibship size and sex mix among the men in our sample. With this in mind, our findings suggest that assortative mating is unlikely to contribute to the positive effects among men at higher parities. Furthermore, these results suggest that previous findings of assortative mating on family size are driven by preferences, values or dispositions transmitted across generations rather than being an effect of sibship size itself.

[19] Using data on British men and women, Murphy (2006) finds evidence of such assortative mating on sibship size.

[20] `https://www.ssb.no/en/statistikkbanken`, Table 08451: Live births, by parity, cohabitation status of mother.

Table 8: Partner attributes

	Men			Women			
	(1) Red.form	(2) IV est.	(3) Dir.Eff.	(4) Red.form	(5) IV est.	(6) Dir.Eff.	(7) Diff.
Birth rank	0.000	0.000	-0.006	0.005	0.089	-0.007	-0.004
	(0.008)	(0.150)	(0.016)	(0.008)	(0.135)	(0.015)	(0.012)
Sibship size	0.008	0.148	0.007	0.004	0.065	-0.000	0.005
	(0.009)	(0.159)	(0.017)	(0.010)	(0.157)	(0.018)	(0.013)
N. of sisters	0.008	0.150	0.006	0.008	0.128	0.004	0.001
	(0.007)	(0.121)	(0.013)	(0.007)	(0.112)	(0.013)	(0.010)
N. of brothers	-0.000	-0.002	0.001	-0.004	-0.063	-0.005	0.004
	(0.007)	(0.120)	(0.013)	(0.007)	(0.119)	(0.013)	(0.010)
Mixed sex sibship	-0.002	-0.034	0.006	0.006*	0.098*	0.000	-0.008*
	(0.003)	(0.056)	(0.006)	(0.003)	(0.052)	(0.006)	(0.005)

Note: The samples are men and women registered with at least one child, who are born in Norwegian families with at least two children, where the two first children are registered with the same mother and father and are born between 1960 and 1969. * $p < 0.10$,** $p < 0.05$, *** $p < 0.01$.

6 Concluding discussion

While fertility is consistently positively correlated across generations, our results show that the causal effect of an additional sibling on own fertility follows a more complex pattern. Under the assumption that the effect of sibship sex composition is fully channeled through fertility in adulthood, our results show that a second sibling causes some men who would have otherwise remained childless to have two children, while it keeps some women from proceeding to having a third child. Through empirical analysis of potential mediators (Section 5), as well as testing hypothesis of parity-specific effects (Section 4.1), we can go some way in distinguishing between the potential causal drivers of these results. As both our expectations and the estimated effects depend on the index person's sex, results for men and women will be discussed separately.

In Section 2.1, two explanations of a positive effect among men were suggested: Men could imitate the family size of their parents – leading in particular to a preference for three child families – or an additional sibling could increase a more general "family orientedness", giving effects at all parities. The results in Section 4.1 favors the latter explanation, showing that the effect of an additional sibling can be observed at all parity transitions. Furthermore, our analysis of mechanisms reveal that partnership dynamics is affected affected in both generations in the male sample: Men from larger families are less likely to experience parental divorce, and more likely to get married themselves. Taken together, these findings points towards that an additional sibling has a positive effect on the family environment in which men grow up, leaving them more positive towards family life in general in adulthood.

We suggested two causal drivers of a negative effect among women: An additional sibling could reduce the monetary resources available to the index person, hence reducing fertility through the income effect. Alternatively, women who have an additional sibling could be more aware of the strains of living in large families – for adults as well as children – and thus choose to limit their own family size. As the roles of both adults and children were highly gendered when our index cohort grew up – and remains so to some extent in the period they had their fertile years – we expected such negative effects mediated by belief formation to be relevant for women only.

We tend to believe in the latter explanation for two reasons. First, the analysis of changes in parental income reveals that the negative effects of childbearing on mother's earnings – and hence the depletion of resources – is relatively stronger in the male than in the female sample. If depletion of resources were driving our results, we would thus expect effects to be more negative among men than among women – while our results reveal the opposite. The differential effects on mothers' earnings also imply that mothers girls put more hours into paid work than mothers of boys – leaving fewer hours for home production. Previous studies show that the time mothers spend with their children is surprisingly unaffected hours in paid work, while teenage girls help out substantially more at home than teenage boys. Thus, we expect that the mothers in the girl sample are able to work longer hours because they have a better "support team" at home – possibly leaving their daughters with a less favorable impression of life in large families.

Furthermore, the belief based explanation clearly predict that women raised in large families would avoid starting larger families themselves – which is exactly the pattern revealed by the parity specific analysis in Section 4.1: Women who grow up in three child families are particularly reluctant to have a third child themselves. Our explanation is further corroborated by the finding that family instability – commonly known to reduce fertility – is not higher among women from larger families, and thus unlikely to drive the results.

Finally, it is noteworthy that our results are highly unlikely to be mediated by an effect of sibship size on educational attainment, as our analysis of mechanisms reveal that educational attainment is unaffected by sibship size in our sample. This is reassuring, as our findings of positive effects among men and negative among women are exactly the opposite of what we would expect were the effects mediated by substitution.

The mechanisms drawn upon in this paper bear resemblance to the mechanisms elaborated in the literature on fertility contagion (Bernardi and Klaerner 2014). In this literature, it is emphasized that fertility is contagious through social networks largely because information of the consequences of fertility choices is imperfect – and individuals draw upon their own experiences and network as a source of such information. Furthermore, it is underlined that fertility contagion can be positive or negative – depending on the character of the information transmitted.

While we draw upon the literature of fertility contagion for explanations, our study also has important implications for this strain of demographic research. Though opening for the theoretical possibility of negative effects, most studies of fertility contagion consistently find effects to be positive. However, controls for unobserved heterogeneity is usually only partial, and upwards bias due to similarity within networks and families can thus not be omitted. This is clearly the case for the intergenerational correlation in fertility, which is likely *more positive* than the effect of an additional sibling on fertility, due to similarity between parents and children on unobservable characteristics. This study provides an empirical example of negative fertility contagion between generations. Our findings indicate that in order to ensure lasting high levels of fertility, policies should ensure that the living conditions for children and adults in large families are not too straining.

References

Aassve, Arnstein, Elena Meroni and Chiara Pronzato. 2012. "Grandparenting and childbearing in the extended family." *European Journal of Population/Revue européenne de Démographie* 28(4):499–518.

Angrist, Joshua D. and William N. Evans. 1998. "Children and Their Parents' Labor Supply: Evidence from Exogenous Variation in Family Size." *The American Economic Review* 88(3):pp. 450–477.
URL: *http://www.jstor.org/stable/116844*

Axinn, William G and Arland Thornton. 1996. "The influence of parents' marital dissolutions on children's attitudes toward family formation." *Demography* 33(1):66–81.

Becker, Gary. 1991. *A Treatise on the Family.* MA: Cambridge: Harvard University Press.

Ben-Porath, Yoram and Finis Welch. 1976. "Do Sex Preferences Really Matter?" *The Quarterly Journal of Economics* 90(2):285–307.
URL: *http://ideas.repec.org/a/tpr/qjecon/v90y1976i2p285-307.html*

Bernardi, Laura. 2003. "Channels of social influence on reproduction." *Population Research and Policy Review* 22(5-6):427–555.

Bernardi, Laura and Andreas Klaerner. 2014. "Social networks and fertility." *Demographic Research* 30(22):641–670.
URL: *http://www.demographic-research.org/volumes/vol30/22/*

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

Black, Sandra E, Paul J Devereux and Kjell G Salvanes. 2010. "Small family, smart family? Family size and the IQ scores of young men." *Journal of Human Resources* 45(1):33–58.

Blake, Judith. 1989. "Number of siblings and educational attainment." *Science* 245(4913):32–36.

Bütikofer, Aline. 2011. Sibling Sex Composition and Cost of Children. Technical report.

Cools, Sara. 2013. Having it all: how children affect the work and wages of men and women. PhD thesis Department of Economics, University of Oslo.

De Haan, Monique. 2010. "Birth order, family size and educational attainment." *Economics of Education Review* 29(4):576–588.

Diekmann, Andreas and Kurt Schmidheiny. 2004. "Do Parents of Girls Have a Higher Risk of Divorce? An Eighteen-Country Study." *Journal of Marriage and Family* 66(3):651–660.

Downey, Douglas B. 1995. "When bigger is not better: Family size, parental resources, and children's educational performance." *American Sociological Review* pp. 746–761.

Easterlin, R. A. and E. M. Crimmins. 1985. *The Fertility Revolution. A Supply-Demand Analysis.* University of Chicago Press.

Emery, Thomas. 2013. "Intergenerational transfers and European families: Does the number of siblings matter?" *Demographic R* 29(10):247–274.

Evertsson, Marie. 2006. "The reproduction of gender: housework and attitudes towards gender equality in the home among Swedish boys and girls1." *The British journal of sociology* 57(3):415–436.

Gager, Constance T, Teresa M Cooney and Kathleen Thiede Call. 1999. "The effects of family characteristics and time use on teenagers' household labor." *Journal of Marriage and the Family* pp. 982–994.

Gauthier, Anne H, Timothy M. Smeding and Frank F Furstenberg. 2004. "Are parents investing less time in children? Trends from selected industrial countries." *Population and Development Review* 30(4):647–672.

Gini, Corrado. 1951. "Combinations and sequences of sexes in human families and mammal litters." *Acta genet* 2:220–244.

Goodsell, Todd L, Spencer L James, Jeremy B Yorgason and Vaughn RA Call. 2013. "Intergenerational Assistance to Adult Children Gender and Number of Sisters and Brothers." *Journal of Family Issues* p. 0192513X13497348.

Hardoy, Inés and Pål Schøne. 2008. "Hvor mye betyr barn for lønnsforskjeller mellom kvinner og menn? [How significant are children in explaining gender wage differences?]." *Tidsskrift for samfunnsforskning* 49:3–36.

Hayford, Sarah R. 2009. "The evolution of fertility expectations over the life course." *Demography* 46(4):765–783.

Imbens, Guido W and Joshua D Angrist. 1994. "Identification and Estimation of Local Average Treatment Effects." *Econometrica* 62(2):467–75.
URL: *http://ideas.repec.org/a/ecm/emetrp/v62y1994i2p467-75.html*

Kolk, Martin. 2014. "Understanding transmission of fertility across multiple generations–Socialization or socioeconomics?" *Research in Social Stratification and Mobility* 35:89–103.

Kotte, Markus and Volker Ludwig. 2011. "Intergenerational transmission of fertility intentions and behaviour in Germany: the role of contagion." *Vienna Yearbook of Population Research* pp. 207–226.

Kravdal, Øystein and Ronald R Rindfuss. 2008. "Changing relationships between education and fertility: A study of women and men born 1940 to 1964." *American Sociological Review* 73(5):854–873.

Kreyenfeld, Michaela. 2004. "Fertility decisions in the FRG and GDR: an analysis with data from the German Fertility and Family Survey." *Demographic Research* 3(11):276–318.

Kuziemko, Ilyana. 2006. Is having babies contagious? Estimating fertility peer effects between siblings. Technical report Princeton University.

Lyngstad, Torkild Hovde and Alexia Prskawetz. 2010. "Do siblings' fertility decisions influence each other?" *Demography* 47(4):923–934.

Murphy, M. 2006. *Agent-Based Computational Modelling. Applications in Demography, Social, Economic and Environmental Sciences.* Heidelberg: Physica-Verlag HD chapter The Role of Assortative Mating on Population Growth in Contemporary Developed Societies, pp. 61–84.

Murphy, Michael. 2013. "Cross-National Patterns of Intergenerational Continuities in Childbearing in Developed Countries." *Biodemography and social biology* 59(2):101–126.

Park, Hyunjoon. 2008. "Public policy and the effect of sibship size on educational achievement: A comparative study of 20 countries." *Social Science Research* 37(3):874–887.

Rijken, Arieke J and Aart C Liefbroer. 2009. "Influences of the family of origin on the timing and quantum of fertility in the Netherlands." *Population studies* 63(1):71–85.

Spitze, Glenna and Katherine Trent. 2006. "Gender Differences in Adult Sibling Relations in Two-Child Families." *Journal of Marriage and Family* 68(4):977–992.

Starrels, Marjorie E and Kristen E Holm. 2000. "Adolescents' plans for family formation: Is parental socialization important?" *Journal of Marriage and Family* 62(2):416–429.

Tanskanen, Antti O, Markus Jokela, Mirkka Danielsbacka and Anna Rotkirch. 2014. "Grandparental Effects on Fertility Vary by Lineage in the United Kingdom." *Human Nature* pp. 1–16.

Waynforth, David. 2011. "Grandparental investment and reproductive decisions in the longitudinal 1970 British cohort study." *Proceedings of the Royal Society B: Biological Sciences* p. rspb20111424.

Appendix A

Table A.1: Mean values in additional outcome variables, by index person's sex

	Men		Women	
	Mean	SD	Mean	SD
Mediating outcomes				
Mother's income 1-5	54.88	(51.22)	54.98	(51.03)
Mother's income 6-10	59.24	(55.91)	59.63	(55.56)
Mother's income 11-15	83.35	(65.94)	84.66	(65.97)
Father's income 1-5	196.09	(64.81)	196.00	(64.46)
Father's income 6-10	232.01	(84.29)	231.72	(83.99)
Father's income 11-15	251.53	(100.10)	251.71	(100.63)
Secondary educ. at 19	0.32	(0.47)	0.41	(0.49)
Income 18-20	72.17	(49.88)	55.53	(37.70)
Parents married at 28	0.74	(0.44)	0.73	(0.44)
Joint outcomes				
Secondary educ. at 40	0.70	(0.46)	0.68	(0.47)
Lower tert. educ. at 40	0.29	(0.45)	0.36	(0.48)
Higher tert. educ. at 40	0.09	(0.29)	0.06	(0.24)
Income 36-40	335.75	(228.57)	208.47	(127.62)
Married at 40	0.50	(0.50)	0.56	(0.50)
Divorced at 40	0.11	(0.32)	0.16	(0.37)
Partner's family characteristics				
Birth rank	2.11	(1.22)	2.12	(1.21)
Sibship size	3.09	(1.30)	3.21	(1.40)
N. of sisters	1.02	(0.99)	1.06	(1.00)
N. of brothers	1.07	(0.97)	1.14	(1.06)
Mixed sex sibship	0.70	(0.46)	0.68	(0.47)
Same sex sibship	0.30	(0.46)	0.32	(0.47)
N	111110		104687	

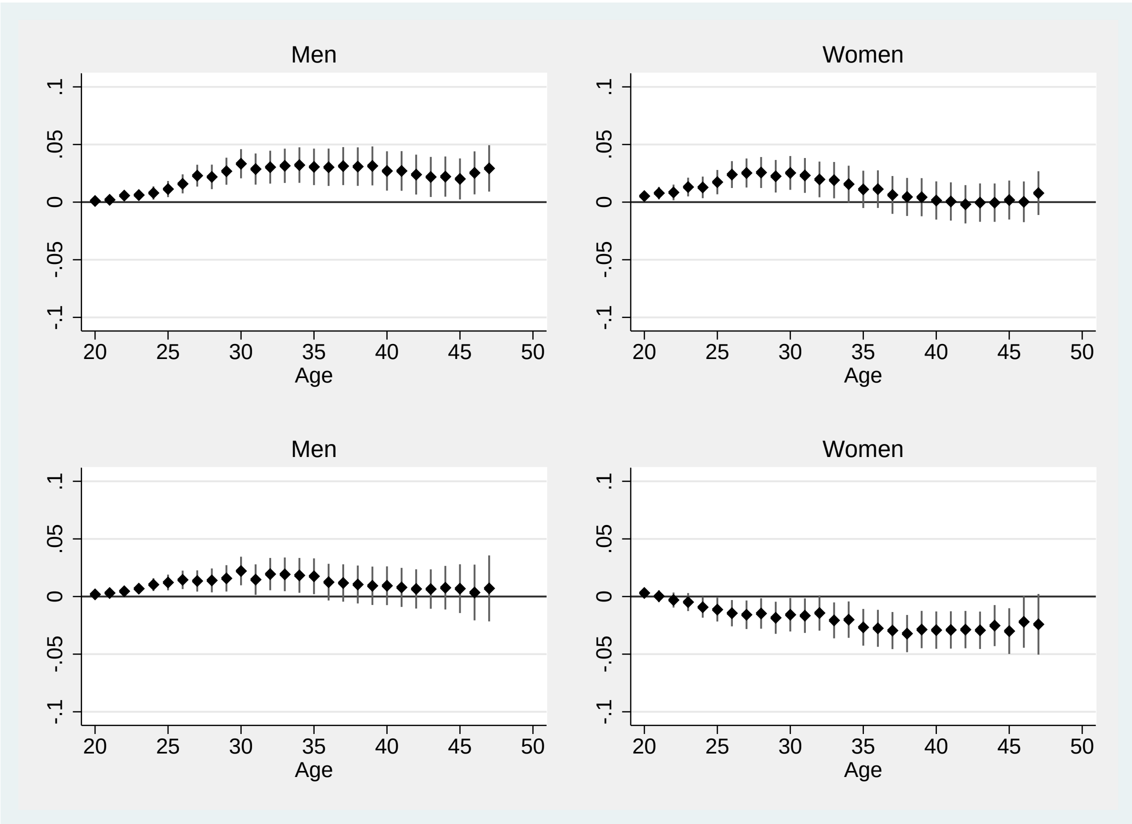
Note: The samples consist of all first- and second born men and women born in Norway between 1960 and 1969 in families with at least two children, where the two first children are registered with the same mother and father. Income is measured in 1000 CPI-adjusted (1998) NOK. Standard deviations in parentheses.

Table A.2: Balancing test of family background variables

	All	1955-1964	1960-1969	1965-1974	1970-1979	1975-1984
	(1)	(2)	(3)	(4)	(5)	(6)
First born's birth year						
- year 1	-0.000	0.002	-0.000	-0.002	-0.003	-0.000
	(0.001)	(0.006)	(0.002)	(0.002)	(0.002)	(0.002)
- year 2	-0.000	-0.000	-0.002	0.001	0.003	-0.000
	(0.001)	(0.006)	(0.002)	(0.002)	(0.002)	(0.002)
- year 3	0.000	0.000	-0.002	0.000	-0.002	0.001
	(0.001)	(0.005)	(0.002)	(0.001)	(0.002)	(0.001)
- year 4	0.000	-0.001	-0.004*	0.002**	0.006***	0.000
	(0.001)	(0.004)	(0.002)	(0.001)	(0.002)	(0.001)
- year 5	-0.001**	-0.001**	-0.004*	-0.000	-0.002	-0.000
	(0.001)	(0.000)	(0.002)	(0.000)	(0.002)	(0.000)
- year 6	0.001	0.000	0.004*	0.003	0.001	0.001
	(0.001)	(0.000)	(0.002)	(0.002)	(0.002)	(0.002)
- year 7	0.000	0.000	0.002	0.001	-0.001	0.000
	(0.001)	(0.000)	(0.002)	(0.002)	(0.002)	(0.002)
- year 8	0.001	0.000	0.005***	0.005**	-0.002	-0.002
	(0.001)	(0.000)	(0.002)	(0.002)	(0.001)	(0.002)
- year 9	0.000	0.000	0.000	-0.003	0.000	0.004*
	(0.001)	(0.000)	(0.001)	(0.002)	(0.001)	(0.002)
- year 10	-0.001	0.000	0.000	-0.006***	-0.000	-0.003
	(0.001)	(0.000)	(0.000)	(0.002)	(0.000)	(0.002)
Mother's age at first birth						
- $<$20 years	0.000	0.005	-0.001	0.000	0.001	-0.000
	(0.001)	(0.005)	(0.002)	(0.002)	(0.002)	(0.002)
- 20-24 years	-0.001	-0.012**	-0.005*	-0.002	-0.005*	-0.003
	(0.001)	(0.006)	(0.003)	(0.003)	(0.003)	(0.003)
- 25-29 years	0.001	0.006	0.006**	0.001	0.003	0.002
	(0.001)	(0.004)	(0.002)	(0.002)	(0.003)	(0.003)
- 30-34 years	-0.001	0.000	0.001	0.001	0.001	0.001
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)
- $\geq$35 years	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Father's age at first birth						
- $<$20 years	0.000	0.001	0.001	0.001	-0.000	-0.001
	(0.000)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
- 20-24 years	0.000	-0.000	0.002	-0.002	0.001	0.001
	(0.001)	(0.006)	(0.003)	(0.003)	(0.003)	(0.003)
- 25-29 years	-0.000	-0.000	-0.005*	-0.000	-0.001	0.001
	(0.001)	(0.006)	(0.003)	(0.003)	(0.003)	(0.003)
- 30-34 years	0.000	0.001	0.002	0.001	-0.001	-0.002
	(0.001)	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)
- $\geq$35 years	-0.000	-0.002	0.001	0.002	0.001	0.001
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Distance first and second born						
- $<$1 year	-0.001***	-0.001	-0.000**	-0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
- 1-2 years	0.001*	0.001	0.002	0.005**	0.004**	0.001
	(0.001)	(0.006)	(0.003)	(0.002)	(0.002)	(0.002)
- 2-3 years	-0.001	0.004	-0.001	0.000	-0.006**	-0.004
	(0.001)	(0.006)	(0.003)	(0.003)	(0.003)	(0.003)
- 3-4 years	-0.002	-0.005	-0.004	-0.003	-0.001	-0.001
	(0.001)	(0.005)	(0.003)	(0.002)	(0.003)	(0.003)
- 4-5 years	-0.000	0.001	0.001	-0.001	-0.002	0.005**
	(0.001)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
- 5-6 years	0.001	0.000	0.000	-0.000	0.002	-0.003
	(0.001)	(0.000)	(0.001)	(0.001)	(0.002)	(0.002)
- $>$6 years	0.002***	0.000	0.003***	-0.001	0.002*	0.001
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	799254	27820	107245	128881	118691	99821

Note: The samples are all couples with at least two children, where the two first children are both born in Norway in the period 1960-1969 and are registered with the same mother and father. For the means, standard deviations are reported in parentheses, for the estimated differences, standard errors are in parentheses. * $p < 0.10$,** $p < 0.05$, *** $p < 0.01$.

Figure A.1: The effect of sibship size on number of children in adulthood. Results from separate models for each age.



Spikes show 90% confidence intervals. All models control birth year fixed effects for the index person, dummies for birth cohort of index person's parents (5-year categories) and dummies for distance in years between the two first siblings.

Appendix B: Complier characteristics

Table B.1: Complier characteristics

Variable	Mean (1)	First stage *SameSex* (2)	CCR *SameSex* (3)	CCR *BoyBoy* (4)	CCR *GirlGirl* (5)	Difference (6)
Mother's age at first birth						
- <20 years	0.18	0.049	0.79	0.90	0.67	0.23
- 20-24 years	0.61	0.061	0.99	0.93	1.05	-0.13
- 25-29 years	0.20	0.070	1.14	1.24	1.04	0.19
- 30-34 years	0.0094	0.096	1.56	1.26	1.88	-0.61
Father's age at first birth						
- <20 years	0.034	0.029	0.47	0.50	0.45	0.050
- 20-24 years	0.42	0.062	1.01	1.07	0.95	0.12
- 25-29 years	0.38	0.061	0.98	0.99	0.98	0.013
- 30-34 years	0.12	0.072	1.17	1.00	1.37	-0.38
- ≥35 years	0.041	0.060	0.97	0.92	1.03	-0.11
- secondary educ.	0.13	0.067	1.08	1.12	1.04	0.086
- lower tert. educ.	0.082	0.065	1.06	0.95	1.18	-0.23
- higher tert. educ.	0.0042	0.024	0.39	0.13	0.75	-0.63
- secondary educ.	0.30	0.069	1.12	1.22	1.01	0.21
- lower tert. educ.	0.14	0.082	1.32	1.35	1.30	0.049
- higher tert. educ.	0.047	0.081	1.31	1.23	1.40	-0.17
Mother's income						
- missing info.	0.90	0.061	0.99	0.99	0.99	0.0050
- <1 BA	0.028	0.042	0.68	0.86	0.49	0.37
- [1-2) BA	0.025	0.053	0.87	0.84	0.89	-0.050
- [2-3) BA	0.017	0.062	1.01	0.80	1.20	-0.40
- [3-4) BA	0.012	0.11	1.84	1.83	1.85	-0.027
- [4-5) BA	0.0095	0.079	1.29	0.59	2.12	-1.53
- [5-6) BA	0.0030	0.084	1.37	2.53	0.16	2.37
- [6-7) BA	0.00064	0.057	0.92	0.83	1.05	-0.23
- ≥7 BA	0.00035	0.044	0.72	1.67	-5.3e-16	1.67
Father's income						
- missing info.	0.68	0.057	0.92	0.91	0.93	-0.018
- <1 BA	0.0093	0.086	1.39	0.93	1.86	-0.93
- [1-2) BA	0.017	0.058	0.94	1.04	0.84	0.20
- [2-3) BA	0.030	0.066	1.08	1.34	0.80	0.54
- [3-4) BA	0.061	0.066	1.08	1.11	1.05	0.064
- [4-5) BA	0.088	0.065	1.05	0.90	1.21	-0.31
- [5-6) BA	0.057	0.086	1.40	1.85	0.95	0.91
- [6-7) BA	0.026	0.073	1.18	1.06	1.31	-0.24
- ≥7 BA	0.029	0.056	0.90	0.62	1.23	-0.62
Distance first and second born						
- <1 year	0.0011	0.036	0.59	1.51	-0.48	1.98
- [1-2 years	0.25	0.042	0.69	0.72	0.65	0.066
- [2-3) years	0.35	0.065	1.06	1.02	1.11	-0.092
- [3-4) years	0.22	0.081	1.31	1.23	1.39	-0.16
- [4-5) years	0.11	0.049	0.79	0.97	0.61	0.37
- [5-6) years	0.046	0.067	1.08	1.15	1.01	0.15
- >6 years	0.030	0.057	0.92	0.79	1.09	-0.30

Note: The samples are all couples with at least two children, where the two first children are both born in Norway in the period 1960-1969 and are registered with the same mother and father. For the means, standard deviations are reported in parentheses, for the estimated differences, standard errors are in parentheses. * $p < 0.10$,** $p < 0.05$, *** $p < 0.01$.

Table B.2: Complier characteristics

Variable	Mean (1)	First stage *SameSex* (2)	First stage *BoyBoy* (3)	First stage *GirlGirl* (4)
Mother's age at first birth				
- <20 years	0.18	0.049	0.054	0.042
- 20-24 years	0.61	0.061	0.056	0.067
- 25-29 years	0.20	0.070	0.074	0.066
- 30-34 years	0.0094	0.096	0.076	0.12
Father's age at first birth				
- <20 years	0.034	0.029	0.030	0.028
- 20-24 years	0.42	0.062	0.064	0.060
- 25-29 years	0.38	0.061	0.059	0.062
- 30-34 years	0.12	0.072	0.060	0.087
- ≥35 years	0.041	0.060	0.055	0.065
- secondary educ.	0.13	0.067	0.067	0.066
- lower tert. educ.	0.082	0.065	0.057	0.075
- higher tert. educ.	0.0042	0.024	0.0075	0.048
- secondary educ.	0.30	0.069	0.073	0.064
- lower tert. educ.	0.14	0.082	0.081	0.082
- higher tert. educ.	0.047	0.081	0.074	0.089
Mother's income				
- missing info.	0.90	0.061	0.060	0.063
- <1 BA	0.028	0.042	0.051	0.031
- [1-2) BA	0.025	0.053	0.051	0.057
- [2-3) BA	0.017	0.062	0.048	0.076
- [3-4) BA	0.012	0.11	0.11	0.12
- [4-5) BA	0.0095	0.079	0.036	0.13
- [5-6) BA	0.0030	0.084	0.15	0.010
- [6-7) BA	0.00064	0.057	0.050	0.067
- ≥7 BA	0.00035	0.044	0.10	-3.3e-17
Father's income				
- missing info.	0.68	0.057	0.055	0.059
- <1 BA	0.0093	0.086	0.056	0.12
- [1-2) BA	0.017	0.058	0.062	0.053
- [2-3) BA	0.030	0.066	0.081	0.051
- [3-4) BA	0.061	0.066	0.067	0.066
- [4-5) BA	0.088	0.065	0.054	0.077
- [5-6) BA	0.057	0.086	0.11	0.060
- [6-7) BA	0.026	0.073	0.064	0.083
- ≥7 BA	0.029	0.056	0.037	0.078
Distance first and second born				
- <1 year	0.0011	0.036	0.090	-0.030
- 1-2 years	0.25	0.042	0.043	0.041
- 2-3 years	0.35	0.065	0.061	0.070
- 3-4 years	0.22	0.081	0.074	0.088
- 4-5 years	0.11	0.049	0.058	0.038
- 5-6 years	0.046	0.067	0.069	0.064
- >6 years	0.030	0.057	0.047	0.069

Note: The samples are all couples with at least two children, where the two first children are both born in Norway in the period 1960-1969 and are registered with the same mother and father. For the means, standard deviations are reported in parentheses, for the estimated differences, standard errors are in parentheses. * $p < 0.10$,** $p < 0.05$, *** $p < 0.01$.