The causal effect of sibship size on fertility in adulthood*

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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.

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1 Introduction

It is a well known sociological fact that children are similar to their parents. Intergenerational correlations are observed in many important areas of adult life, such as education, economic resources and personality traits (see e.g. D'Addio et al. (2007) for an overview). Fertility behavior is no exception – numerous studies have documented that fertility is positively correlated across generations (see e.g. Kolk (2013)).

Genetic predispositions, as well as shared social circumstances, are plausible explanations of this intergenerational correlation in fertility. The birth of an additional sibling may however also be *causally* linked to fertility in the next generation, as it changes many important aspects of a child's upbringing: The amount of resources available to each child is reduced, the child's beliefs about the consequences of fertility choices may change, and parents' fertility behavior may causally impact children's own fertility preferences in adulthood. To the best of our knowledge, no previous study has estimated the causal effect of sibship size on fertility in adulthood. The importance of these mechanisms thus remains unknown.

Importantly, knowledge of the causal effect of sibship size on fertility in adulthood may also cast light on the prospects for future fertility recuperation. According to the influential "low fertility trap" hypothesis (Lutz, Skirbekk and Testa 2006), low fertility in one generation causes low fertility in the next. If there is indeed such a positive causal relationship, the prospects of future fertility recuperation are poor: Once low fertility has emerged, the process towards even lower fertility is self-strengthening by necessity. A negative effect (or no effect) runs counter to the expectations from the low fertility trap hypothesis, making the prospects for future fertility recuperation less gloomy than previously assumed.

Using an instrumental variable approach, we estimate the causal effect of sibship size in family of origin on fertility behavior in adulthood. 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.[1] We study the fertility behavior of Norwegian men and women born in the 1960s, using highly reliable data from Norwegian administrative registers. 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 various age- and parity specific measures. All models are run separately by sex and birth order in order to allow for heterogenous effects.

Our main results are twofold: First, an additional sibling causes some men – who would otherwise have remained childless – to have (two) children in adulthood. Second, an additional sibling causes some women to have two rather than three children. The latter finding runs counter to the expectation that high fertility in one generation necessarily causes high fertility in the next. Girls who grow up in three-child families may be more closely familiar with the strains of larger families, for mothers as well as daughters, than are girls who are raised in two-child families. This 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. For effects that last across generations, pro-natalist policies should not only aim at increasing birth rates: Polices that ease the lives of female members in large families, such as access to child care and job protection during maternity leave, may indeed have positive effects on fertility in the next generation.

2 Predictions from theory

Sibship size is an important factor in the family environment in which children grow up, affecting various aspects of both children's and parents' lives. Having an

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

additional sibling/child changes material conditions in the household, more or less substantially. It 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 affect individuals' own fertility in adulthood. The direction of the effect, however, is not obvious *a priori*, as the following discussion makes clear.

In households with larger sibships, the level of parental resources available to each child is lower – all else equal. 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 more time away from labor market activities to unpaid work at home. The decrease may be substantial, and it is not necessarily fully compensated by an increase in fathers' earnings. 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 in children from larger sibships (Becker 1991).[2]

In sum, the relative resource depletion stemming from larger sibship size would expectedly cause lower fertility in the next generation, through a negative income effect. On the other hand, if sibship size indeed depresses individuals' human capital, this effect may be counteracted by a substitution effect working in the other direction. At lower levels of human capital, the cost of taking time off work to care for children is relatively smaller. At least for women, thus, a decrease in human capital may therefore be expected to give higher fertility.

Aside from its effect on material conditions, sibship size may expectedly influence individuals' fertility preferences, yielding a second mechanism through which sibship

[2]This is seemingly confirmed by 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 (see e.g. Black, Devereux and Salvanes (2005, 2010); De Haan (2010).

size affects fertility behavior in adulthood. In the demographic literature, fertility preferences are consistently found to be *adaptive* – that is, adjusted in accordance with fertility behavior (Hayford 2009). Thus, the birth of an additional child may *cause* parents to prefer a large family more strongly than before, a preference that may in turn be transmitted to their children. *Preference transmission* is considered an important mechanism in the literature on intergenerational transmission of fertility (Kolk 2013). Taken to the extreme, the theory of *imitation* (see e.g. Starrels and Holm (2000)) suggests that individuals use their family of origin as a blueprint for their own family formation, thus making choices that resemble their parents' choices. According to this theory, index persons with a second sibling develop a preference for three-child families themselves. However, transmission of preferences need not be as mechanistic: Growing up in a large sibship may also cause a more general 'family orientedness' – reflected in for instance earlier childbearing in the next generation, rather than direct imitation of the fertility patterns in the family of origin.

In addition to being influenced by material conditions and preferences, individuals make choices based on the beliefs they hold about their consequences. As a last, yet important channel, we consider how the effect of sibship size on fertility in adulthood may be mediated by individuals' access to information through their experience in the family of origin. While (hopefully) bringing joy, an extra child is a time- and effort-consuming addition to the family, adding strain to the lives of adults as well as children. Naturally, individuals have first hand experience only with their own sibship situation, and they must rely on second hand information about life in sibships of other sizes. The strain of having an extra child or sibling may thus not be fully perceived by individuals raised in smaller families. Children may be less than eager to share information of own disadvantages, and it may also be significantly different to *experience* strain and to hear about others' experiences of strain. In the demographic literature, such belief formation through personal experience is often referred to as *social learning* (Bernardi 2003).

The extent to which an additional sibling causes strain clearly depends on gender: An additional younger sibling increases the time children spend on housework – but more so for girls than for boys (Evertsson 2006).[3] Also, while having three children impedes women's careers more than having two children, the negative consequences of parity progression is by far less severe for men than for women (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 above discussion makes clear that the effect of sibship size on fertility in adulthood – as mediated by either material circumstances, preference formation and transmission, or belief formation – could be either positive or negative. The theory of adaptive preferences and that of imitation predict a positive effect of sibship size on fertility in the next generation for both men and women. Based on the theory of imitation, we would in particular expect that growing up in a three-child family causes a preference for having exactly three children. A positive effect could also, at least for women, be the result of 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. If there is indeed such an information asymmetry, we expect a negative causal effect especially for women of sibship size on own fertility in adulthood.

[3]Evertsson use recent data on Swedish children. While data on children's time use is not available for the 1960 cohort, it seems a safe assumption that the gender difference in children's contribution at home has – if anything – *decreased* over time. Thus, for the cohorts of study, we expect that having an additional sibling was substantially more straining for girls than for boys.

3 The instrumental variable approach

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 in adulthood. In order to get around this problem, we 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 instrumental variable 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 number of siblings, but it is uncorrelated with background characteristics of parents (such as fertility preferences) that bear their own influence on children's fertility decisions in adulthood.[4]

We estimate the causal effect of having an additional sibling on fertility in adulthood in two steps, by *two stage least squares* (2SLS) regression. By using only the part of the variation in the outcome that is tied to the sex composition, variation in (initial) fertility preferences between parents of two and three children is held constant. 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. This fertility margin is crucial in the Norwegian setting: Kravdal (1992, p.249) describes the shift from the three- to the two child family as the "key component behind the 'second demographic transition' in Norway".

As the sex composition is strongly significantly correlated with the probability of transgressing to a third child also in Norway (see Section 4.3), there is little reason to

[4]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). 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.

worry about instrument relevance in our case. The exogeneity of the instrument may be more disputable. Simple tests show sex composition by all likelihood is randomly assigned (see Section 4.2), but the is the obstinate menace of direct effects remains: Could sex composition among siblings affect fertility outcomes in adulthood other than via its effect on sibship size?

Research on the relative influence of brothers and sisters on fertility decisions is scarce for women, and, to the best of our knowledge, the question is unexplored with respect to men's fertility decisions. In a large qualitative study of Italian women's fertility, Bernardi (2003) find that sisters are more important than brothers for women's fertility decisions. Lyngstad and Prskawetz (2010) find that Norwegian women's fertility timing is slightly more positively affected by the fertility behavior of a younger brother than that of a younger sister. This may indicate direct effects of sex composition on fertility, leading to a downward bias in the same-sex estimate for women.[5]

A source of direct effects of siblings' sex composition on their fertility in adulthood is suggested by the empirical finding that parents rely relatively more on help from maternal than from paternal grandparents (Aassve, Meroni and Pronzato 2012; Thomese and Liefbroer 2013). As sisters compete for the help from the same (prospective) maternal grandparents, fertility may be lower in sibships where the two first born children are female. However, empirical studies fail to identify that access to help from maternal and paternal grandparents has differential effects on fertility (Aassve, Meroni and Pronzato 2012; Thomese and Liefbroer 2013).

In sum, it seems that direct effects related to social influence might bias the estimates for women *upwards*, while direct effects related to competition for parental

[5]As Lyngstad and Prskawetz (2010) limit their study sample to two-child sibships, women from same-sex sibships will all be the children of parents who could not be moved by the instrument ("never-takers" in the terminology of Angrist and Pischke (2009)), while women from mixed sibships may be the children both of parents who could not and parents who would be moved by the instrument (the latter group thus being "compliers" by the same terminology). The estimated effects may thus to some extent reflect differences in parental fertility preferences, in turn transmitted to their children, between these two groups.

resources might bias their estimates *downwards*. Birth order may further play a role here, as first-born women on average will enter parenthood sooner than their younger sisters, giving rise to different resource situations at the time fertility decisions are made.

4 Data and descriptive results

4.1 Data and 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. The need for reliable data on both family background and on own completed fertility makes us focus on the 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 – and in order to have the sample for first and second born individuals, we condition on both being born during the same time window (1960-1969). In order to increase precision of the first stage, we further exclude families in which the first two children do not share both parents, or where either parent is unknown to the registers.

4.2 Background variables

Descriptive statistics on relevant background characteristics 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 (second column). We see that regarding most background characteristics, such as parents' year of birth, age at entry into parenthood, and education, the samples are identical.[6] The last column reports simple t-tests of

[6]The registration of highest attained education dates only back to 1970, so we would need to assume that parents' education did not change after the second child was born for this characteristic to be exogenous to the instrument. For this reason, we do not include controls for eduction in our main specification, but we have done so for robustness – and the results do not change.

Table 1: Descriptive statistics

	Same sex		Different sex		Difference	
	Mean	SD	Mean	SD	Est.	SE
Distance two first children (years)	2.43	(1.32)	2.45	(1.33)	-0.03***	(0.01)
Boy first	0.53	(0.50)	0.50	(0.50)	0.03***	(0.00)
Boy second	0.53	(0.50)	0.50	(0.50)	0.03***	(0.00)
Mother's						
- year of birth	1941.48	(3.45)	1941.48	(3.47)	-0.00	(0.02)
- age at first birth	22.15	(2.82)	22.17	(2.84)	-0.02	(0.02)
- years of schooling	10.47	(1.98)	10.48	(1.99)	-0.01	(0.01)
- had >2 children	0.67	(0.47)	0.61	(0.49)	0.06***	(0.00)
- n. of children	3.01	(0.99)	2.92	(0.99)	0.10***	(0.01)
Father's						
- year of birth	1938.00	(4.95)	1938.03	(4.96)	-0.03	(0.03)
- age at first birth	25.63	(4.38)	25.62	(4.40)	0.00	(0.03)
- years of schooling	11.21	(2.76)	11.24	(2.77)	-0.03	(0.02)
- had >2 children	0.68	(0.47)	0.62	(0.49)	0.06***	(0.00)
- n. of children	3.06	(1.03)	2.96	(1.03)	0.10***	(0.01)
N	53901		54021		107922	

Note: The sample is all first- and second born individuals of Norwegian couples whose two first children were born in the period 1960-1969. The last column reports estimated differences according to whether the two children share sex or not. For the means, standard deviations are reported in parentheses, for the estimated differences, standard errors are in parentheses. * $p < 0.10$,** $p < 0.05$, *** $p < 0.01$.

whether the background characteristics vary with the sex composition of the first children, and we find no systematic differences for these variables. This is reassuring with respect to the instrument being randomly assigned, as discussed in Section 3. We do, on the other hand, see that the same sex families are on average 6 percentage points more likely to have more than two children, and that they have .1 children more on average, indicating that the instrumental variable indeed satisfies the criterion of relevance in our sample. We estimate the first stage explicitly below.

The first three rows of Table 1 report significant differences according to same sex status also for the distance between the births of the first two children, and for the likelihood that either child is a boy. The latter findings can be explained by a slightly higher propensity in our sample to have a third child if the two first are boys relative to two girls. We have no explanation for the shorter distance between births among same sex families. We note, however, that the difference is very small (though highly statistically significant) – and it is not something we find in other

Table 2: The effect of first two siblings being same sex on sibship size

	Men				Women			
	First born		Second born		First born		Second born	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Same sex	0.059***	0.057***	0.059***	0.055***	0.063***	0.060***	0.063***	0.061***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Birth year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other controls	No	Yes	No	Yes	No	Yes	No	Yes
R2	0.006	0.104	0.007	0.107	0.008	0.110	0.007	0.107
N	55520	55520	55569	55568	52402	52401	52353	52353

Note: Each column presents results from OLS regression of parents' propensity to have a third child on whether their two first children are of the same sex. The samples are all first- or second born individuals of Norwegian couples whose two first children were born in the period 1960-1969. In even-numbered columns controls are dummies 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). *** p < 0.01.

cohorts. We add a control for the distance between births in our main specifications throughout the paper.

4.3 First stage estimates

The first stage in our 2SLS setup is estimation of the relationship between sibship size and sex composition by OLS:

$$SibshipSize_i = \rho SameSex_i + \gamma_Y BirthYear_i + \gamma_X X_i + \nu_i. \tag{1}$$

The instrument is valid only if the instrumental variable significantly affects the instrumented variable, i.e. if ρ is significantly different from zero. Table 2 shows that parents are about six percentage points more likely on average to have had a third child if their two first children are of the same sex (first stage coefficients are somewhat lower for men than for women, reflecting that parents of two boys are slightly more likely to proceed to having a third child than are parents of two girls).

In all specifications we have included dummies for the index person's birth year. In even-numbered columns we have included the background variables on individuals that are determined prior to the birth of the second sibling – that is, prior to the realization of the instrumental variable – that are described above: Dummies 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).[7] Their inclusion does not significantly alter the estimates.

4.4 Outcome variables

The fertility outcomes we consider in this paper concern both quantum and tempo. We evaluate parity specific outcomes by considering separately the probability of having more than 0, 1, 2 and 3 children. In order to capture tempo effects, regression models are run separately for each age from 20 to well past 40 (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 for each yearly increment in age).

Descriptive statistics for the quantum outcomes are displayed in Table 3. The quantum outcomes are all measured at the age 40.[8] As a short-hand tempo outcome, we have also included the individual's age at first birth, though being conditional on having at least one child, this measure is endogenous if sibship size affect individuals' propensity to ever have children. This outcome will therefore not be considered in our analyses later on. As in Table 1, we present the means in outcomes separately for individuals according to instrument status, i.e., whether they belong to sibships in which the first two children are of the same sex or not.

The last column again provides t-tests for differences in these variables by instrument status. In all subgroups but for second born women, mean age at first birth is lower in same-sex sibships than in mixed sibships. Among first born men, those who

[7] As a robustness check, we have also included dummies for the number of years of schooling each parent has, observed in 1970. This inclusion does not alter the estimates. Results are available from the authors upon request.

[8] To be precise, the quantum 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.

Table 3: Mean values in outcome variables, and differences in means by child sex mix

	Same sex		Different sex		Difference	
	Mean	SD	Mean	SD	Est.	SE
Men, first born						
Age at first birth	28.69	(5.53)	28.85	(5.53)	-0.16***	(0.05)
N. children at 40	1.68	(1.23)	1.65	(1.23)	0.03**	(0.01)
Has children at 40	0.76	(0.43)	0.75	(0.43)	0.01**	(0.00)
Has >1 child at 40	0.60	(0.49)	0.59	(0.49)	0.01**	(0.00)
Has >2 children at 40	0.25	(0.43)	0.25	(0.43)	0.01*	(0.00)
Has >3 children at 40	0.05	(0.23)	0.05	(0.22)	0.00	(0.00)
N	28534		26986		55520	
Men, second born						
Age at first birth	28.83	(5.41)	28.99	(5.42)	-0.16***	(0.05)
N. children at 40	1.63	(1.21)	1.62	(1.20)	0.01	(0.01)
Has children at 40	0.75	(0.43)	0.75	(0.43)	0.00	(0.00)
Has >1 child at 40	0.59	(0.49)	0.58	(0.49)	0.00	(0.00)
Has >2 children at 40	0.23	(0.42)	0.23	(0.42)	0.01**	(0.00)
Has >3 children at 40	0.05	(0.21)	0.05	(0.21)	0.00	(0.00)
N	28534		27035		55569	
Women, first born						
Age at first birth	25.71	(5.05)	25.87	(5.08)	-0.16***	(0.05)
N. children at 40	2.01	(1.15)	2.01	(1.16)	0.00	(0.01)
Has children at 40	0.87	(0.34)	0.87	(0.34)	0.00	(0.00)
Has >1 child at 40	0.73	(0.45)	0.73	(0.45)	0.00	(0.00)
Has >2 children at 40	0.33	(0.47)	0.33	(0.47)	-0.00	(0.00)
Has >3 children at 40	0.08	(0.26)	0.07	(0.26)	0.00	(0.00)
N	25367		27035		52402	
Women, second born						
Age at first birth	26.12	(5.15)	26.09	(5.14)	0.03	(0.05)
N. children at 40	1.95	(1.12)	1.98	(1.14)	-0.03***	(0.01)
Has children at 40	0.86	(0.34)	0.86	(0.34)	0.00	(0.00)
Has >1 child at 40	0.72	(0.45)	0.72	(0.45)	-0.01	(0.00)
Has >2 children at 40	0.30	(0.46)	0.31	(0.46)	-0.02***	(0.00)
Has >3 children at 40	0.06	(0.24)	0.07	(0.25)	-0.01***	(0.00)
N	25367		26986		52353	

Note: The sample is all first- and second born individuals of Norwegian couples whose two first children were born in the period 1960-1969. The last column reports estimated differences according to whether the two children share sex or not. 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 4: The correlation between sibship size and completed fertility estimated by OLS

	Men				Women			
	First born		Second born		First born		Second born	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
> 1 sibling	0.122***	0.109***	0.130***	0.115***	0.187***	0.166***	0.219***	0.197***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)	(0.011)	(0.010)	(0.011)
Birth year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other controls	No	Yes	No	Yes	No	Yes	No	Yes
Observations	55520	55520	55569	55568	52402	52401	52353	52353

Note: Each column presents results from OLS regression of number of children in adulthood on whether having more than one sibling in the family of origin. The samples are all first- or second born individuals of Norwegian couples whose two first children were born in the period 1960-1969. In even-numbered columns controls are dummies 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). *** $p < 0.01$.

have a younger brother on average have .03 children more at age 40 than those who have a younger sister. Compared to men with a younger sister, men with a younger brother are more likely to have had both a first, a second and a third child at age 40. Second born men on average have .01 children more if they have an brother than an older sister, but the difference in means by sex composition is not statistically significant. However, second born men with an older brother are significantly more likely to have more than two children at age 40 than second born men who have an older sister. First born women display no differences in fertility quantum according to sibship sex composition. Second born women, on the other hand, have .3 fewer children on average if they are from same-sex sibships. This difference in means is driven by a lower proportion of women with an older sister proceeding to have a third or higher order birth.

These differences in means are the *reduced form estimates* (with no controls) of the effect of being treated by the instrument on fertility. Table 3 thus gives a hint about the direction of the effects to be estimated in Section 5.

4.5 Intergenerational correlations in fertility

Previous research has consistently found the intergenerational correlation in fertility to be positive. Table 4 shows that this is the case also in our sample: The OLS estimates presented there show a strong and positive correlation between sibship size in one generation and fertility in the next for all subsamples.

The OLS estimates show how the average completed fertility among individuals with more than one sibling differs from the average completed fertility among individuals with one sibling only. The odd-numbered columns show basic models, controlling only for the index person's birth year. When further controls are added (even-numbered columns) the estimates decrease slightly – but never significantly – in all subsamples. Growing up with more than one sibling (compared to one sibling only) is correlated with an increase in completed fertility of on average 0.12-0.13 children among men and 0.19-0.22 children among women. The magnitude of the correlations are in line with the strength of the intergenerational correlations in fertility observed in Murphy's (2013) comparative study. The observed gender difference is significant, and resonates with the finding that fertility timing is more strongly transmitted from mothers to daughters than from mothers to sons (see e.g. Kolk (2013); Barber (2001)). Though never significant at the 5%-level, the intergenerational correlation in fertility is consistently stronger for second borns than for first borns.

5 The effect of sibship size on fertility in adulthood

Our main result, the causal effect of sibship size on completed fertility, is displayed in Table 5. We show results from estimating a basic model, including birth year fixed effects for the index person only, and a model including dummies for parents' birth year and distance between the two first born siblings (as described in Section 4.3). Including controls for mothers' and fathers' education does not alter the point estimates, and these results are thus not shown (but they are available upon request).

We present separate estimates for the four subsamples: First and second born

Table 5: The effect of sibship size on own number of children, measured at age 40.

MEN	First borns		Second borns	
	(1)	(2)	(3)	(4)
> 1 sibling	0.478***	0.475***	0.125	0.151
	(0.162)	(0.163)	(0.158)	(0.161)
Birth year FE	Yes	Yes	Yes	Yes
Other controls	No	Yes	No	Yes
Observations	64667	64667	64600	64599

WOMEN	First borns		Second borns	
> 1 sibling	-0.012	-0.008	-0.426***	-0.418***
	(0.146)	(0.151)	(0.150)	(0.149)
Birth year FE	Yes	Yes	Yes	Yes
Other controls	No	Yes	No	Yes
Observations	60869	60868	60936	60936

Note: Each column presents results from 2SLS regression of number of children in adulthood on whether having more than one sibling in the family of origin. The samples are all first- or second born men (upper panel) and women (lower panel) of Norwegian couples whose two first children were born in the period 1960-1969. Having more than one sibling is instrumented by the gender composition of the first two children. In even-numbered columns controls are dummies 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). * $p < 0.10$,** $p < 0.05$, *** $p < 0.01$.

men and women, respectively. There is a positive effect of sibship size on fertility in adulthood among first born men, who will on average have .48 more children when they have additional siblings beyond their younger brother. There is no significant effect on completed fertility for second born men and first born women. For second born women, the effect of increased sibship size is negative: They have about .42 fewer children on average. Thus, the effects are more positive for first borns than for second borns, and more positive for men than for women.

These heterogenous effects differ substantially from the consistently positive intergenerational correlations in fertility presented in Section 4.5. The IV estimates are more positive than the OLS estimates for men, and less positive than the OLS estimates for women. The causal effect of an additional sibing can thus not explain the positive intergenerational correlation in fertility observed among women. This suggests that there are other, non-causal, explanations for the intergenerational correlation in fertility, such as transmission of parents' (initial) fertility preferences.

It is also striking that while the intergenerational correlation in Table 4 is fairly similar for first and second borns, the causal effect of sibship size depends on parity. Across sex, second borns are more negatively affected by the birth of a second sibling than are first borns. While first borns retain their position as the oldest child when a third child is born, second born children are shifted from being the youngest to being middle born. Middle born children do worse with respect to several non-academic outcomes, such as self-esteem (Kidwell 1982) and a vast number of risky behaviors in adolescence (Argys et al. 2007) – a finding that might be explained by parents being more likely to favor first- or last borns than middle borns (Salmon, Shackelford and Michalski 2012; Suitor and Pillemer 2007). The shift to a less advantageous position within the sibship upon the birth of a second sibling, may explain why the causal effect of sibship size is consistently less positive for second borns than it is for first borns.

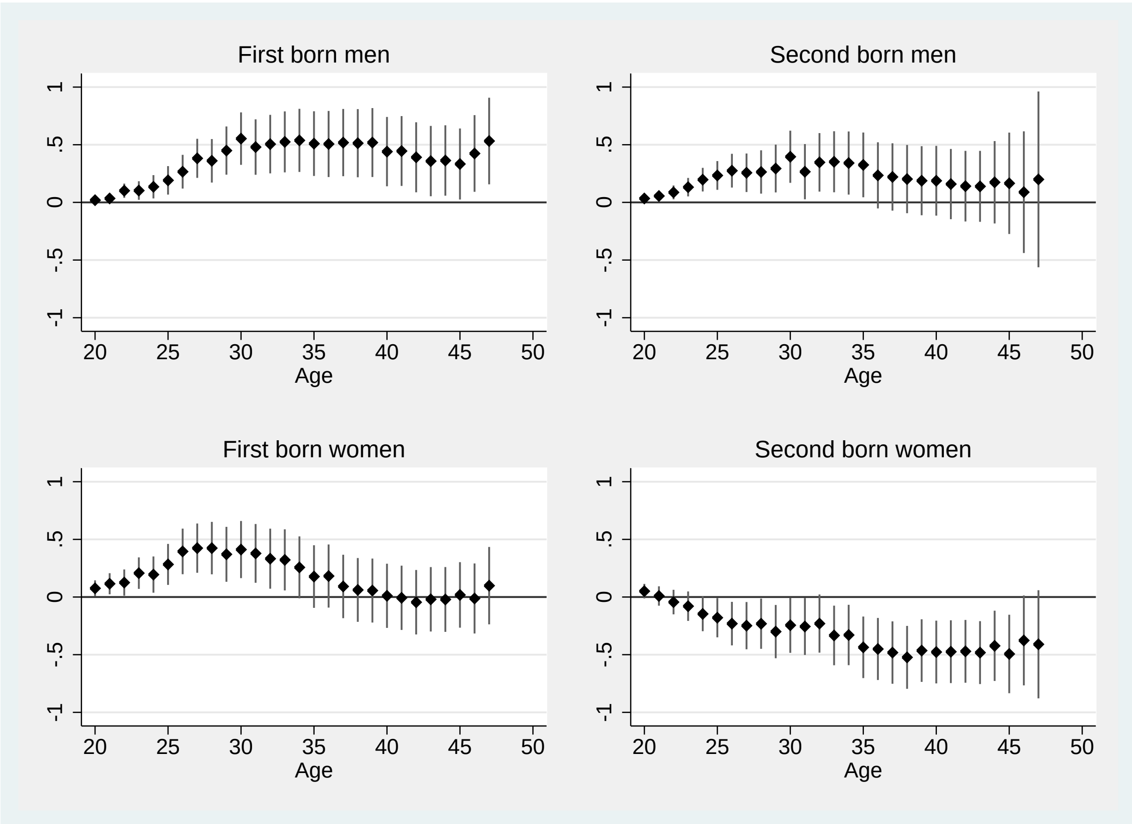
The last column of Table 3 gave the raw difference in fertility outcomes by same sex sibship status. As we discussed in Section 3, inflating this difference by the first stage, as is done by the 2SLS procedure, gives unbiased estimates of the causal effect (the "local average treatment effect", to be precise) in the absence of direct effects of sex composition on fertility in adulthood. If there are direct effects, the whole of the reduced form estimate cannot be attributed to the difference in sibship size, and inflating it by the first stage thus gives a biased estimate.

If having a younger brother, rather than a younger sister, positively affects men's own fertility in adulthood, this could partly explain the positive estimate found for first born men. As fertility contagion is found to run most strongly in female networks, one could argue that a bias in the opposite direction is more plausible, if men are relatively more exposed to "family culture" by having a sister. On the other hand, in the absence of a daughter, parents may (intentionally or not) socialize their sons to be more family-oriented – for instance by pressure for grandchildren, which would otherwise be taken out on a daughter. We cannot therefore rule out an upward bias in our estimates in the male sample, in part explaining the positive effect found for first born men. We are unconvinced, however, that explanations based on direct effects are more plausible than the effect being channeled through sibship size.

Regarding the negative estimates for second born women, competition for grandparental resources may produce a direct effect of sex composition among sisters on their fertility in adulthood. Such competition between sisters has been found to delay parity progression, while quantum effects are found for the transition to parenthood only (Aassve, Meroni and Pronzato 2012). As such, quantum effects at higher parities are least prone to bias from direct effects. Reassuringly, parity specific analysis (Section 5.2) show that the quantum effects among women are indeed driven by effects at higher parities.

We now turn to potential explanations of the causal effect of sibship size on fertility. Transmission of adaptive preferences – as well as imitation – could drive the positive causal effects of sibship size on fertility observed among men. Regarding the negative effects observed among women, other causal explanations must be sought. Depletion of resources in the family of origin may depress fertility in the next generation through an income effect, and having a second sibling may provide women with information of the strains of living in large families. In Section 6, we assess the plausibility of each of these causal drivers by analysing possible mediators of the causal effect of sibship size estimated above.

Figure 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.

5.1 Timing effects

In absence of – or in addition to – effects on completed fertility, sibship size may affect fertility *timing*. Timing effects have substantial demographic consequences, as earlier childbearing shortens generational length and increases period fertility (Goldstein, Lutz and Scherbov 2003). We capture tempo effects by estimating linear probability models separately for each age, from 20 to 47 years, of the individual. For ease of exposition, estimates are presented in Figure 1 (with 90% confidence intervals).

The figure reveals that fertility behavior is affected in all four subsamples, despite the absence of quantum effects among second born men and first born women. For first born women, there are strong positive and statistically significant tempo effects of sibship size on their own number of children up until the age of 35, from which point on the effect approaches zero and stays there throughout. Second born men follow a similar, though somewhat weaker, pattern until their 30s. After the age of 35, the estimated effect, though consistently positive, is no longer statistically significant in this groups.

The finding that timing of births is affected by sibship size, while completed fertility remains unchanged resonates well with the demographic literature. In particular, public policies are often found to affect fertility tempo in absence of lasting effects on completed fertility (see e.g. Gauthier (2007) for an overview). With respect to theoretical explanations, effects of sibship size on fertility timing are unlikely to be channeled through imitation: Individuals do not imitate the number of children their parents had by shifting childbearing to younger ages. Explanations related to transmission of (adaptive) preferences may be more relevant: If parents become more family oriented as a consequence of having an additional child, and transmit this feature to their children, it may translate into a preference for earlier childbearing in the next generation.

In the subsamples where sibship size do affect completed fertility, the effects on completed fertility emerge as tempo effects from early on. The positive quantum effect found for first born men is visible as a tempo effect already from the early 20s. Second born women constitute the only subsample without positive tempo effects. A negative effect slightly below -.2 emerges in the important childbearing years from 25 to 32, grazing statistical significance. From age 35 onwards, a negative quantum effect remains stable at about -.45.

Figure 1 also provides a test of the validity of fertility at age 40 as a quantum measure. Our choice quantum measure is motivated by data quality concerns. To the extent that estimates at higher ages are similar to those at age 40, this strengthens the validity of our measure of completed fertility.[9] Reassuringly, Figure 1 shows that this is indeed the case.

5.2 Parity specific effects

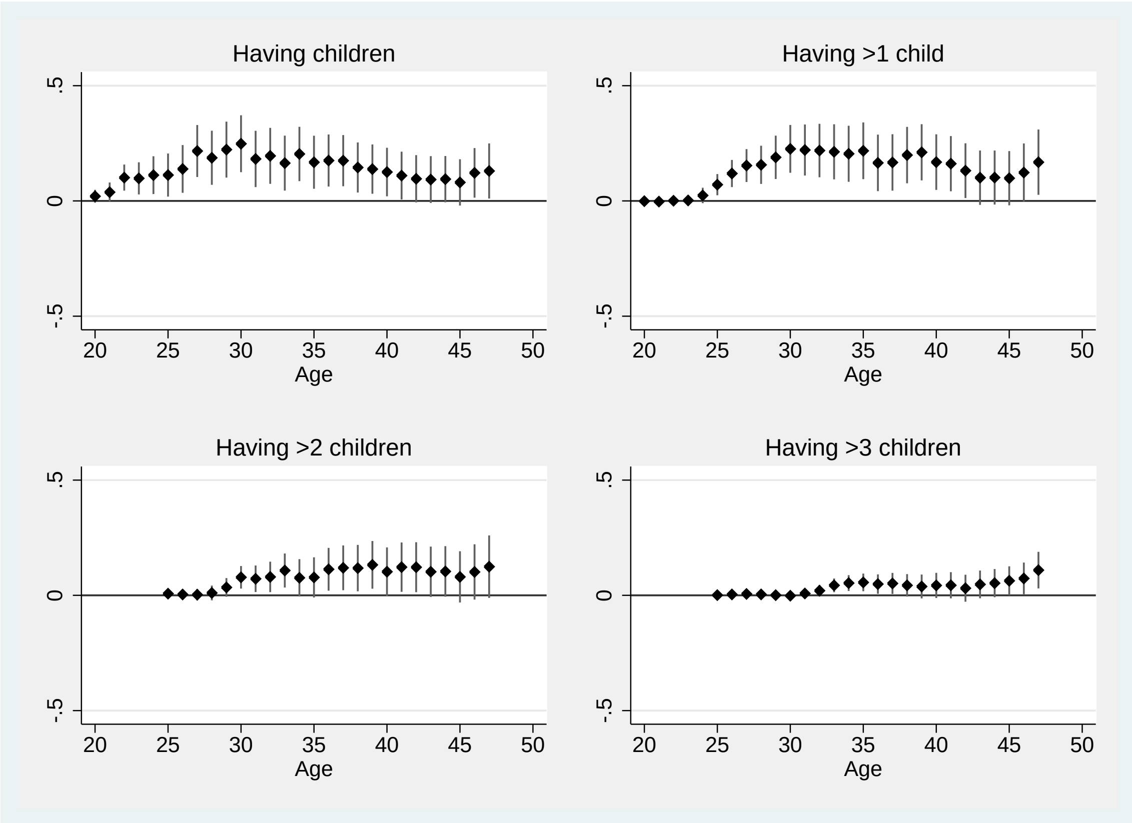
Determinants of fertility are usually found to impact different parity transitions in differing ways. We would therefore expect this to hold also for sibship size. As a single number, the linear quantum effects estimated above conceal information about which parity transitions are most affected by sibship size. A more detailed picture of how sibship size affects fertility choice may enable us to better understand the causal drivers of the estimated quantum effects. In the following section, we therefore describe parity specific effects by estimating separate models taking the probability of having *at least* 1, 2, 3 and 4 children as the dependent variable.[10] Again, each outcome is modeled at different ages, i.e. every year between the index person's age 20 and age 45, thereby capturing tempo effects. With four subsamples, four (parity specific) outcomes and 25 ages, the resulting number of estimates is 400. For ease of exposition, we present these results graphically (tables are available from the authors upon request). We present only the results from the specification

[9] Beyond this age, standard errors tend to increase drastically, as the individuals born towards the end of the cohort's birth window are no longer part of the sample.

[10] The outcomes are described in more detail in Section 4.4.

with exogenous controls. Inclusion of further controls (results available on request) does not alter the estimates substantially.

Figure 2: The effect of sibship size on the probability of having at least 1, 2, 3, and >3 children. Results from separate models for each age. First born men.

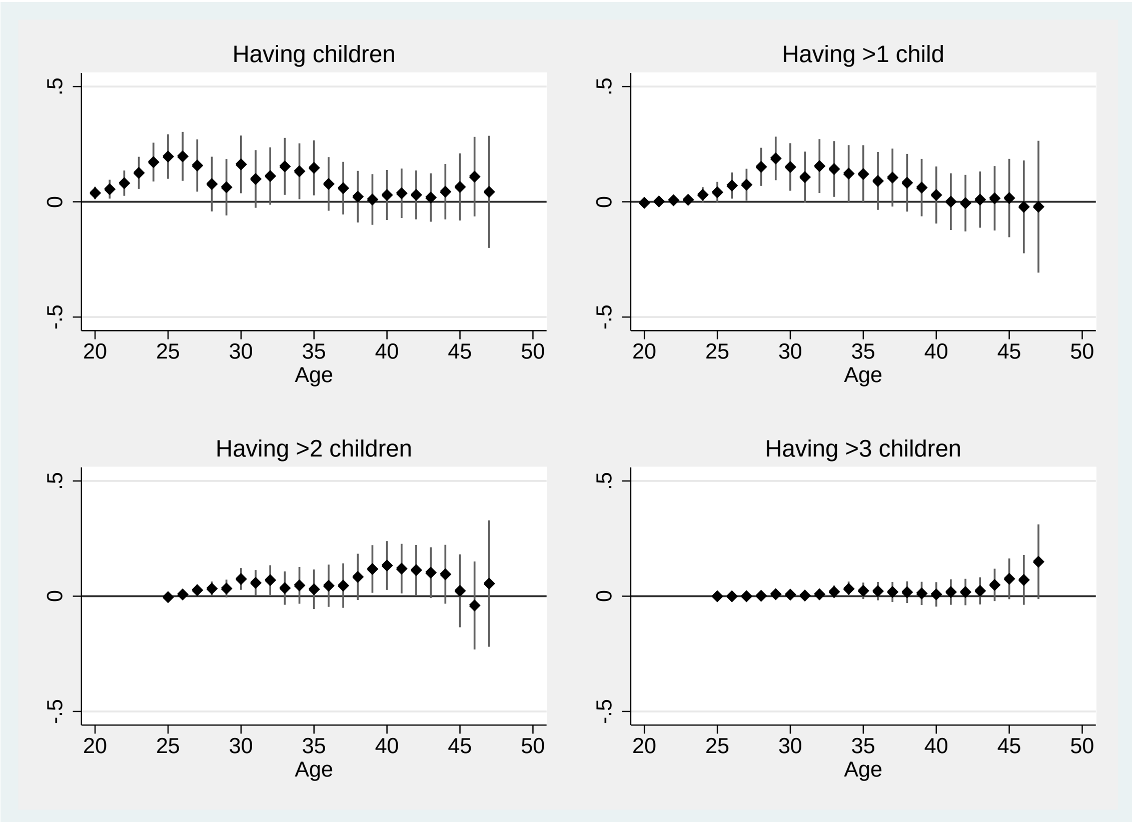


Spikes show 90% confidence intervals. All models control birth year fixed effects for the index person, dummies for birth cohort of index person's parents (5-year categories) and dummies for distance in years between the two first siblings.

Figure 2 displays the parity specific estimates for the first born men in our sample. In this group, a second sibling increases the probability of ever having a child, and has an effect of similar magnitude on the probability to have two or more children (rather than none). While men with a second sibling are more likely on average to have a third child, this estimate does not differ significantly from zero. A second sibling has no significant effect on higher-order births. In sum, having an additional sibling moves some first born men who otherwise would have remained childless to have at least two children.

If men use their family of origin as a blueprint for own family formation – as suggested by the literal interpretation of the theory of imitation – we would expect that men who have an additional sibling are more likely to have three children themselves in adulthood. The results from the parity specific models run counter to this prediction. Rather than causing a preference for large families, it seems that an additional sibling shifts some men into a preference for having a family *at all* – rather than remaining childless. In light of the strong two-child norm in our index cohort, it is unsurprising that men go on to have a second child once they have entered parenthood.[11]

Figure 3: The effect of sibship size on the probability of having at least 1, 2, 3, and >3 children. Results from separate models for each age. Second born men.



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.

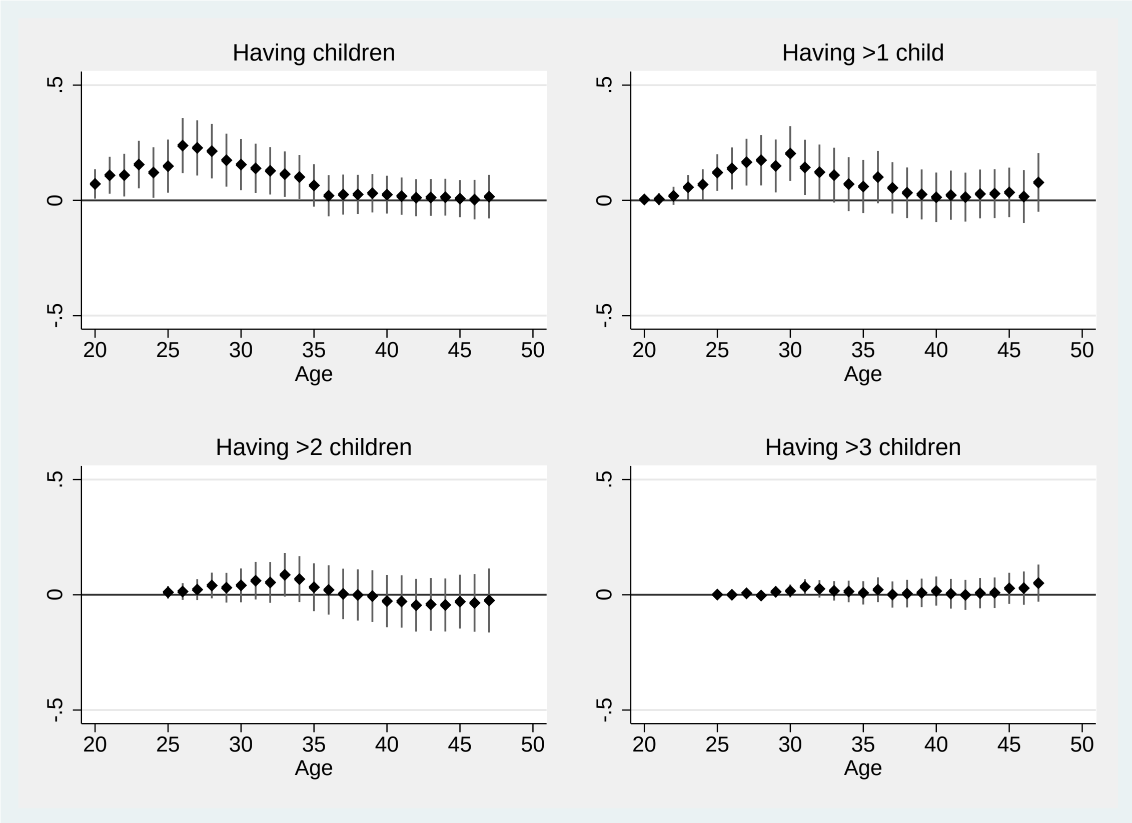
[11] Among Norwegian men born in the 1960s, about 1 in 4 were childless at age 40, while only around 15% had one child only (`https://www.ssb.no/en/statistikkbanken`, Table 07870).

Figure 5 displays the parity specific estimates for the second born women in our sample. Second born women seem to postpone childbearing if they have a second sibling: The point estimates indicate that they enter motherhood later, and have a second child later, though the pattern of postponement is rarely significant at the 10% level. Second born women are however strongly significantly less likely throughout to have a third or higher order birth if they have a younger sibling. These quantum effects at higher parities are fully driving the negative effect on number of children found in Table 5. Having a second sibling, thus, does not make these women reluctant to *enter* parenthood, but it leads to a preference for having relatively fewer children of their own. This points towards the explanation that second born girls in large families perceive having a large family as more straining than do girls with only one sibling.

The distribution of the effects for women by parity is reassuring with respect to the plausibility of direct effects. While lack of grandparental resources have been found to hinder the transition to parenthood, no permanent effects are found at higher parities. If second born women have lower fertility because the compete with an older sister the resources of the same maternal grandparents, we expected the effects to be most marked for the transition to parenthood. However, the negative quantum effect we find for second born women is driven by reluctance to continue childbearing at higher parities. As competition over grandparental resources is an unlikely explanation of effects at this parity, the explanation that the effects are indeed channeled through the instrument is strengthened.

The distribution of tempo effects by parity for second born men and first born women also deserves brief comment. The tempo effects found in Figure 1 are distributed by parity as expected: Figure 3 shows that an additional sibling induces younger brothers to enter parenthood earlier, and also to proceed earlier to have a second child. From about the age 40 and onwards, however, none of these effects persist, and no significant effects are found for higher order births. Like second born

Figure 4: The effect of sibship size on the probability of having at least 1, 2, 3, and >3 children. Results from separate models for each age. First born women.



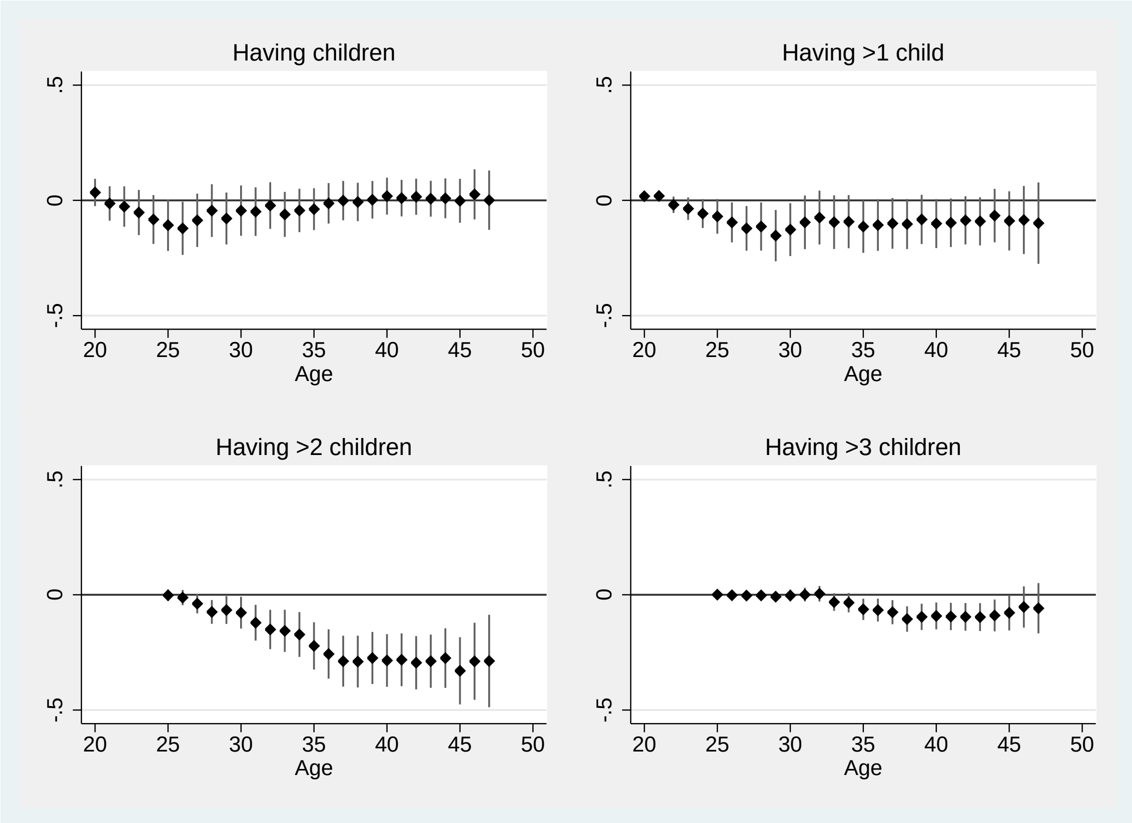
Spikes show 90% confidence intervals. All models control birth year fixed effects for the index person, dummies for birth cohort of index person's parents (5-year categories) and dummies for distance in years between the two first siblings.

men, first born women (Figure 4) are induced to enter parenthood earlier if they have a second sibling, and to proceed earlier to have a second child. Beyond the age of 30, however, first born women do not differ significantly in fertility due to sibship size.

6 Mediating outcomes

In Section 2, we outlined three social mechanisms through which sibship size in one generation could affect fertility in the next: Material conditions in the family of origin, (adaptive) preferences and perceptions or beliefs about how fertility choices

Figure 5: The effect of sibship size on the probability of having at least 1, 2, 3, and >3 children. Results from separate models for each age. Second born women.



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.

affect adult life of men and women. Norwegian administrative registers contain data that may shed light on some of these channels, especially on the role of changes in material conditions caused by sibship size.

The effect of an additional sibling may be mediated by material conditions through two different mechanisms, potentially working in opposite directions. First, if parents' total income falls as a result of the addition to the family, family size in the next generation may be reduced through the income effect. Additionally, sibship size may depress children's educational achievement, potentially increasing fertility in the next generation, at least among women. To see how these mediating factors are affected in our subsamples, we use detailed data on the index person's educa-

Table 6: Mediating outcomes

	Men		Women	
	First born	Second born	First born	Second born
Years of schooling	0.380	0.085	-0.129	0.515
	(0.462)	(0.483)	(0.407)	(0.409)
Avg. mother's income	-40074.713***	-52945.782***	-11862.310	-1469.095
	(8248.647)	(8620.095)	(8076.302)	(7957.973)
Avg. father's income	-1887.186	-4598.136	-8421.552	-5271.326
	(12830.386)	(13128.293)	(12573.734)	(12266.838)
Parents stay married	0.148*	0.164**	0.075	0.057
	(0.081)	(0.081)	(0.086)	(0.086)

Note: Each cell presents results from 2SLS regression of number of children in adulthood on whether having more than one sibling in the family of origin. The samples are all first- or second born individuals of Norwegian couples whose two first children were born in the period 1960-1969. Having more than one sibling is instrumented by the gender composition of the first two children. All estimations control for dummies 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). * $p < 0.10$,** $p < 0.05$, *** $p < 0.01$.

tional achievements (dating back to 1970) and on parents' earned income (dating back to 1967).

Estimates are presented in Table 6. The first row shows the 2SLS estimates for how sibship size affects the education of the individuals in our sample (measured in number of years of schooling attained at the age of 40). We find no significant effects here, meaning that we cannot explain the negative effect of sibship size on second born women's fertility in adulthood by their having (significantly) higher education as a result of an additional sibling.[12]

The next three rows of Table 6 show the 2SLS estimates of how parents' income was affected by the additional sibling during the childhood years of the individuals in our sample. Income is measured as the average over the years between the second born child's age 5 and 18. As expected, the additional sibling depresses mother's income in the men's sample by a considerable – and statistically significant – amount. Less expectedly, however, the reduction in mothers' income is less pronounced, and not statistically significant, in the women's sample. While a second sibling depresses

[12] We have estimated the effect on education separately for non-linear indicators of various education levels, and there are no significant effects at age 40 at either level. 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).

father's income in all samples, these effects are never significantly different from zero.

If depletion of economic resources did drive the observed fertility effects, we would expect to see the strongest negative effect of sibship size on family income among women, for whom the negative fertility effects are observed. The difference between the effect of an additional sibling on family income in the boy sample and the girl sample reveals the opposite pattern. As such, depletion of resources seems an unlikely mediator of our results.

The difference in estimates according to sample has two possible explanations: Either sex composition directly influences parents' (mothers') labor supply, or the effect of having a third child on parents' labor supply is affected by whether parents (mothers) have a "team" of two boys or two girls at home. The first explanation involves a violation of the exclusion restriction. We stress, however, that for this explanation to hold, it is not enough that children's sex has a direct effect on labor supply; it must be the sex composition of the two first children that matters. It would have to be having two boys (two girls) relative to one boy and one girl that has this large direct effect. We tend to believe in the second explanation: That having two girls rather than one of each sex is a different matter than having two boys relative to one of each sex, when it comes to how a third child affects mothers' labor supply.

If mothers of sons indeed shift more time to home production upon the birth of a third child than do mothers of daughters, the experience of growing up in a large family will differ quite markedly between the girl sample and the boy sample. 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. 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. 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[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.

As discussed in Section 2, the experience of growing up in a large family may affect fertility in the next generation through belief formation/social learning. To the extent that growing up in a large sibship implies having to participate extensively in housework for girls – but not for boys – girls will to a larger extent than boys learn of the disadvantages of large families when they have a second sibling. Girls may also observe their mothers being in a "time squeeze", spending long hours in paid work as well as extensive time on child rearing. Aiming to avoid ending up in a similar situation, girls who have an additional sibling could be reluctant to start large families themselves.

The last row of Table 6 presents estimates of the effect of sibship size on another potentially important formational mediating outcome: Parents' marital stability. Again, the difference in estimates between men and women (though not statistically significant) may point to both direct effects and a *mediation* of effects. As unions with a higher number of children are consistently found to be more stable, it seems fully plausible that the observed effects are indeed channeled through the instrumented variable. Direct effects will emerge only if having two boys (two girls) compared to a mixed sibship reduces divorce risk through other channels than sibship size. This possibility can of course not be excluded, but in the European context, no consistent relationship between child sex and divorce risk is found (Diekmann and Schmidheiny 2004). Studying Swedish families, Andersson and Woldemicael (2001) find that among two-child families, divorce risk is lower among parents of mixed

[13]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`)

sibships, while parents of three children have the highest divorce risk if all children are female.[14] In absence of direct effects, the differential effects in the boy and girl sample may result from the sex composition of the two first born children mediating the effect of the third sibling on divorce risk, that is, a third child may protect more strongly against divorce if the two first born children are boys than if the two first borns are of the opposite sex.

Children from intact homes may have a more positive experience of family life in their childhood, leading to increased fertility in the next generation. However, there is no consistent empirical evidence that this is indeed the case. While Axinn and Thornton (1996) find that children of divorced parents have lower intended fertility than children from intact homes, Kreyenfeld (2004) fail to find any correlation between parent's divorce and fertility behavior in adulthood. Rijken and Liefbroer (2009) find that a high level of conflict in family of origin reduces fertility in adulthood, but find no effect of parental divorce on fertility after control for conflict level. As such, it is not obvious that parents' marital stability is an important mediator of our results.

7 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. A second sibling causes some (first born) men who would have otherwise remained childless to have two children, while it keeps some (second born) women from proceeding to having a third child.

As outlined in Section 2, the theory of imitation as well as that of adaptive preferences predict a positive effect of sibship size on fertility in the next generation. From the theory of imitation, we particularly expected that growing up in a three-

[14]By conditioning on number of children, Andersson & Woldemicael (2001) sort all never-takers with two same sex first borns into the two-child sample. Thus, what is seemingly effects of child sex in this study may actually be driven by differences in parents' complier status.

child family would give a preference for the same family size in adulthood. This prediction is brusquely rejected for women, and the positive effect found among men does not correspond to this expectation either, as it is seemingly driven by men who are shifted from childlessness to having no more than two children. We therefore believe the transmission of adaptive preferences to be the main explanation for the positive causal effect of sibship size on men's fertility in adulthood.

An additional sibling reduces the amount of resources available to each child, which could in turn have a negative impact on fertility in the next generation through the income effect. However, while we observe negative effects of sibship size among women only, and sibship size reduces mother's earnings very modestly in the female sample (and much more in the male sample), resource depletion seems to be an unlikely explanation of our results. Finding no significant effects of sibship size on educational attaiment, we also consider this an unlikely mediator of our results.

As mediated by beliefs, we expected causal effects to vary by sex. In particular, we hypothesized that girls who grow up with more than one sibling are more closely familiar with the disadvantages of large families, than are girls who grow up with one sibling only. This difference in beliefs could in turn be expected to cause the former group of women to limit their family size relative to the latter, and it could plausibly explain the negative intergenerational effect of sibship size that we find for women. We note with particular interest that a second sibling causes some women to avoid having three children themselves in adulthood. Our results thus indicate that fertility decisions are deliberative rather than based on imitation. Exposure to high fertility is in itself not sufficient to cause high fertility in the next generation.

Our results establish an interesting and novel connection between family size in one generation and male childlessness in the next. Though the increase in male childlessness has attracted substantial attention among demographers (see e.g. Lappegård, Rønsen and Skrede (2011)), its link with intergenerational transmission of fertility has been less explored. Our results indicate that growing up in a large family reduces the probability that men remain childless. The extent to which the decrease in three-child families in one generation is linked to the increase in male childlessness in the next generation stands out as an interesting topic for future research.

Our findings refute that high fertility in one generation necessarily causes high fertility in the next. As such, it casts doubt on whether low fertility in one generation necessarily causes low fertility in the next – as assumed in the "low fertility trap" hypothesis (Lutz, Skirbekk and Testa 2006). If life in large families is too straining, high fertility in one generation actually depresses fertility in the next. This underlines that policies that ease the lives of girls and women in large families, such as high-quality childcare and job security during maternity leave, may be crucial in order to allow for positive fertility transmission. If such policies are in place, the prospects for future fertility recuperation may be better than previously assumed (Lutz, Skirbekk and Testa 2006). Had the birth of a second sibling caused less strain for mothers and daughters, the causal effect of an additional sibling may indeed have been different for women. In order to further explore this potentially important mechanism, research on the interlinkages between the (subjective) experience of living in a large family and fertility decisions in adulthood is clearly called for.

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