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Abstract:
Fertility contagion through social networks increasingly attracts the interest of demographers. While these theories propose a causal mechanism, they are rarely put to test in a plausibly causal statistical design. This study applies quasi-experimental techniques to distinguish network effects from selection. Using contagion between siblings as an empirical example, we draw data from Norwegian administrative registers (N approx.170 000 men and women). We use twin births and the sex composition of children as random fertility shocks. We find no consistent significant effects of random shocks to a sibling's fertility on ego's fertility. First born women have larger families over time if a younger sibling chooses to have three children, as captured by the same sex instrument. We find no evidence that similarity strengthens contagion.

Keywords: Fertility, Social networks, Social contagion, Instrumental Variables

JEL classification: J13, C26, C32

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Address: Rannveig Kaldager Hart, Statistics Norway, Research Department.
E-mail: r.k.hart@sosiologi.uio.no

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Sammendrag

Påvirkes fruktbarhetsavgjørelser av barnefødsler blant venner og familie? Dette spørsmålet blir gjenstand for stadig mer demografisk forskning. For å besvare spørsmålet trengs et forskningsdesign som fanger opp (kausale) effekter, og tar hensyn til at individer i samme nettverk kan oppføre seg likt også av andre grunner enn at de påvirker hverandre. Denne studien undersøker om søskens fruktbarhetsatferd påvirker hverandre ved hjelp av instrumentvariable. Data om fødsler, slekstskap og sosioøkonomisk bakgrunn er hentet fra administrative registre for et analyseutvalg på ~ 170 000 personer. Vi utnytter at både tvillingfødsler og kjønnssammensetningen av de to førstefødte barna i en familie skaper tilfeldig variasjon i familiestørrelse. Vi finner ingen konsistent sammenheng mellom slik tilfeldig variasjon i ett (voksent) søskens familiestørrelse, og sannsynligheten for å få (flere) barn hos et annet (voksent) søsken. Det er en tendens til at førstefødte kvinner får flere barn hvis et yngre søsken har valgt å få et tredje barn. Vi finner ikke støtte for at det er sterkere smitte mellom søsken av samme kjønn.

1 Introduction

The fertility behavior of one individual can affect the fertility choices of another. When friends and family have children, individuals' preferences for and knowledge about life with children may change. Contagion is typically expected to be stronger between individuals who are relatively similar, and who keep in frequent contact (Bernardi and Klaerner 2014).

Previous studies show that fertility timing correlates positively between siblings (Kuziemko (2006) and Lyngstad and Prskawetz (2010), but see Kotte and Ludwig (2011) for a counterexample), between friends (Balbo and Barban 2014; Lois and Becker 2014), and among colleagues (Pink et al. 2014). However, as friends, siblings and colleagues all tend to be similar, the coordinated fertility behavior may be a result of common unobservable characteristics rather than network effects (Manski 1995). Such selection on unobservables is likely to bias the estimates upwards (Wooldridge 2010).

In this study we aim to estimate fertility contagion net of unobserved heterogeneity, using sibling networks as an empirical example. We draw data on fertility behavior from Norwegian administrative registers (N $\sim$ 170 000). Because siblings usually keep in contact throughout adulthood and often are relatively similar, they are expected to affect each others' fertility. However, they must also be expected to share features like fertility preferences, which cannot be perfectly measured and netted out by the researcher. Our method for handling this endogeneity is to estimate the effect of a random shock to the sibling's fertility decision on ego's fertility outcomes. To the best of our knowledge, using exogenous variation to identify a causal effect on fertility has been done only for teenage fertility, indicating both negative (Yakusheva and Fletcher 2015) and positive (Monstad et al. 2011) contagion.

Two types of random shocks to fertility have been used extensively in the demographic and economic literature: Twin births and the event of having two children of the same sex. A twin birth is an unintended family increase, which is arguably random (conditional on the mother's age and SES) (Rosenzweig and Wolpin 1980a,b). Having two children of the same sex (also a random event) is known to increase the preference for having a third child among a subset of the population (Gini 1951; Angrist and Evans 1998).

As there is no spacing between twins, twinning at second birth is arguably a more straining experience than choosing to have a third child due to a preference for sex mix. Moreover, the twin instrument captures the effect of a third birth among couples who would otherwise have preferred to have only two children whereas the estimated effect when using the same sex instrument regards those parents who will stop at two children if they have one boy and one girl, but will have at least three children if the two first have the same sex. We exploit the different nature of these shocks to investigate whether a more strainful and less wanted fertility experience yields a more negative social contagion.

2 Mechanisms of contagion

When a sibling has an additional child, ego may learn of the (dis)advantages of relatively large families (*social learning*), and experience positive or negative feelings toward childbearing (*emotional contagion*) (Bernardi and Klaerner 2014). This may in turn lead to positive or negative effects on fertility, depending on how ego and the sibling perceives the fertility shock: A more straining event would be expected to lead to transmission of a relatively more negative effect. Also, variation in planning status of births may matter for fertility contagion: Unintended births (as captured by the twin instrument) are on average linked to adverse outcomes for children and parents (Abajobir et al. 2016; Barber and East 2009; David 2006; Myhrman et al. 1995), perhaps indicating a more straining experience for parents.

Also from a resource perspective, the transmission between siblings could be both positive and negative. When a sibling expands their family, this is likely to change the availability of practical help and of resources flowing from the sibling, though it is not obvious how. If it is a zero-sum game, the practical help available to the index person will be reduced, as siblings with larger families take up more resources both from grandparents and other family members, and will themselves have less resources to the disposal of others. On the other hand, an increase in sibling's family size may induce a shift towards joint family activities, potentially increasing ego's gain from having children (see Schoen et al. (1997) for a general example). Additionally, the birth of an additional niece or nephew may reduce the social pressure exerted for grandchildren put upon ego, potentially reducing ego's family size.

Arguably mechanisms for transmission depends of network characteristics. For social learning or belief formation, similarity is crucial (Bernardi 2003; Pink et al. 2014). Particularly, as fertility decisions influences the lives of men and women differently, we expect the experiences of siblings of the same sex to be perceived as a more relevant source of information. In line with this, Bernardi (2003) find that women tend to use other women – rather than men – as sources of information and emotional impressions toward childbearing.

Finally, birth order may matter in its own right for fertility contagion. Expectedly, older siblings will influence younger siblings more than the other way around: First borns will experience most transitions first due to being older, and a self-reinforcing mechanism may emerge in that younger siblings grow used to using their older siblings as role models in childhood, and continue to do so in adulthood.

3 Empirical approach

3.1 Data

All data are drawn for administrative registers. Individuals are linked to their siblings, parents and children by way of a personal identification number. We use two instrumental variables for siblings' number of children: The sex mix of the sibling's first two children and whether the sibling had twins at second birth. Both instruments move the sibling's number of children from two to more than two children, and both instruments are only defined for siblings who have at least two children. Therefore, our study sample consists of men and women whose sibling had a second child in the period 1980-1999.[1] In order to have well-defined sibling relations, we restrict the sample to men and women who are either first or second born in their family of origin.

In order to obtain consistent IV estimates, we avoid control variables that could themselves be influenced by the instrumental variable. All control variables should therefore be observed prior to or at the realization of the instrument. Regarding

[1] We also exclude individuals whose sibling had twins at first birth from the sample.

potential socioeconomic controls, detailed measures of personal income go only as far back as 1992 in Norwegian register data. This imposes a limitation on the number of suitable control variables. We include controls for calendar year of siblings' second birth, age of sibling and sibling's partner at second birth, distance to sibling in years, age difference between sibs two first born children. The controls enter as yearly dummies, except for the controls for sibling's and sibling's partner's age at their second birth, where we use dummies for five year age brackets.

3.2 Identification strategy

In order to capture the effect of a sibling's family size on the index person's fertility behavior, we utilize two different instrumental variables (IVs) for the sibling's number of children. A valid instrumental variable will increase the sibling's fertility, but will at the same time be uncorrelated with any (unobserved) characteristics that could cause siblings' childbearing patterns to be related. While both instruments are extensively used in estimating the effect on family size on other outcomes, application to fertility outcomes remain rare (exceptions are Cools and Hart (2017) and Kolk (2015)).

An IV strategy using *twinning at second birth* as instrumental variable captures the effect of a third child for individuals who would otherwise have had only two children. As zero spacing between the second and third child is potentially strainful (at least in the short run), the twin instrument captures the effect of a comparatively stressful fertility event. As IVF is associated with higher risk of twinning, it is of particular concern to show that this instrument is (conditionally) independent on observable characteristics.

An IV strategy using children's *same sex* as an instrumental variable exploits the fact that parents are more likely to have a third child if the two first born children are of the same sex. Child sex is random, and therefore the variation in family size induced by child sex is random too. In contrast to the twin instrument, the additional births induced by the same sex instrument are intended and wanted. The two instrumental variables thus capture effects of quite different fertility shocks.

Our outcome variable is ego's number of children, measured five and ten years after the sibling had a second child (T5 and T10). While the twin instrument increases family size immediately, the same sex instrument increases the probability of a third birth, which on average happens 2-3 years after the first. Descriptive statistics for the outcome variables are shown in Table 1. The lag also allows time for conception and gestation. Sizable effects *before* the sibling's second child is born indicate that instrument validity is compromised. We test for this by estimating effects on ego's fertility the same year and five years before the sibling's second child is born (T0 and T−5, respectively). Reassuringly, our results do not indicate that there are such premature effects.

For all outcomes and subsamples, we present three types of estimates: Reduced form (RF) estimates give the effect of the sibling having twins or two first born children of the same sex on ego's number of children. IV estimates give the effect of the sibling's family size on ego's family size, under the assumption that the effect of twinning/sex composition is channeled solely through a change in the sibling's family size. Finally, OLS estimates report how ego's family size varies with the sibling having a third child in our sample.

Table 1: Descriptive statistics on outcome variables by subsample

	MEN				WOMEN			
	First born		Second born		First born		Second born	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
N. children at T−5	0.56	(0.84)	0.14	(0.45)	0.94	(0.97)	0.29	(0.63)
N. children at T0	1.12	(1.08)	0.47	(0.80)	1.55	(1.07)	0.80	(0.96)
N. children at T+5	1.58	(1.16)	0.99	(1.06)	1.93	(1.07)	1.41	(1.09)
N. children at T+10	1.82	(1.18)	1.46	(1.16)	2.08	(1.07)	1.83	(1.08)

Note: The sample is Norwegian firstborn and second-born men and women whose sibling had a second child during the period 1980-1999.

4 Results

4.1 Descriptive statistics and balancing tests

Table 2 gives the mean values (and standard deviations) of background characteristics that are included in all our regressions, split by whether the index person has a sibling with same sex children or not (panel A) or a sibling with twins at second birth or not (panel B). For the same sex instrument, we do not expect these characteristics to differ between the two samples, and the t-tests in the last column show that they hardly differ significantly, and never substantially. Twin births are however known to be random only when conditioning on parents' age (Black et al. 2005). We see indeed that parents of twins are on average a year older than parents who had two singleton births. They have also waited longer since their first birth – potentially due to fertility problems. Since twinning has become more common over the years, the twin second births in our sample on average take place about a year later than the other births.

The statistics displayed in Table 2 typically serve as "balancing checks", arguing that the instrumental variables are indeed randomly allocated. Since twinning is only conditionally random, we have estimated how the instrumental variables

Table 2: Background characteristics by instrument status

Panel A						
Instrument Z is same sex	$Z = 0$		$Z = 1$		t-test	
	Mean	SD	Mean	SD	Diff.	SE
Ego's birth year	1963.26	(5.85)	1963.29	(5.83)	-0.03	(0.02)
Distance ego and sibling	2.81	(1.51)	2.82	(1.51)	-0.01*	(0.01)
Sibling's age at 2nd birth	28.63	(4.01)	28.61	(4.00)	0.02	(0.02)
Sibling's partner's age at 2nd birth	29.40	(4.55)	29.36	(4.56)	0.04*	(0.02)
Sibling's spacing 1st and 2nd child	3.31	(1.78)	3.31	(1.78)	0.01	(0.01)
Birth year sibling's 2nd child	1991.52	(5.26)	1991.52	(5.26)	0.01	(0.02)
Panel B						
Instrument Z is twin2	$Z = 0$		$Z = 1$		t-test	
	Mean	SD	Mean	SD	Diff.	SE
Ego's birth year	1963.27	(5.84)	1963.15	(5.64)	0.12	(0.10)
Distance ego and sibling	2.82	(1.51)	2.85	(1.49)	-0.03	(0.03)
Sibling's age at 2nd birth	28.62	(4.00)	29.64	(4.23)	-1.02**	(0.07)
Sibling's partner's age at 2nd birth	29.38	(4.55)	30.37	(4.85)	-0.99**	(0.08)
Sibling's spacing 1st and 2nd child	3.31	(1.78)	3.65	(2.19)	-0.34**	(0.03)
Birth year sibling's 2nd child	1991.52	(5.26)	1992.36	(5.06)	-0.84**	(0.09)

Note: The sample is Norwegian firstborn and second-born men and women whose sibling had a second child during the period 1980-1999. † $p < 0.10$,* $p < 0.05$, ** $p < 0.01$.

Table 3: Balancing tests

	Z is same sex		Z is twin2	
	(1)	(2)	(3)	(4)
Sib schoolyears T−1	-0.016	-0.010	0.154**	-0.018
	(0.011)	(0.010)	(0.051)	(0.047)
Sib income T−1	-93.559	-63.637	14117.119**	471.436
	(454.920)	(371.646)	(2049.190)	(1675.586)
Ego schoolyears T−1	0.014	0.018†	0.119*	-0.005
	(0.011)	(0.011)	(0.050)	(0.048)
Ego income T−1	-712.241	-475.395	10759.499**	-984.921
	(457.407)	(411.208)	(2062.250)	(1855.599)
Ego n. children T−1	0.004	0.006	0.077**	-0.005
	(0.004)	(0.004)	(0.018)	(0.017)
CIA covariates	No	Yes	No	Yes

Note: The sample is Norwegian firstborn and second-born men and women whose sibling had a second child during the period 1980-1999. Standard errors in parentheses. † $p < 0.10$,* $p < 0.05$, ** $p < 0.01$.

predict a number of other background characteristics, observed the year prior to the birth of the sibling's second child (T0), such as ego's schooling, income and number of children and sibling's schooling and income. If the instruments are unconditionally independent, no significant associations should be found. Under conditional independence, any significant associations should disappear after controls (even-numbered columns).

Table 3 displays two sets of OLS estimates. In the odd numbered columns, the estimates gives the raw association of the instrument (same sex in panel A, twinning at second birth in panel B) with the outcome variable given in the row header, including no other covariates. Then in even numbered columns, the estimates give the corresponding association once we control for all the variables in Table 2.[2]

[2]The controls enter as yearly dummies, except for the controls for sibling's and sibling's partner's age at their second birth, where we use dummies for five year age brackets.

The estimates are as expected: For the same sex instrument, there are no significant associations with or without covariates beyond what one should expect from chance. Siblings of twin parents have significantly higher educational attainment, higher income and more children. These differences disappear once age is held constant (even-numbered columns).

4.2 Exogenous variation from twinning

Table 4 shows the effect of a sibling having twins on second birth on ego's number of children, measured five and ten years after the sibling's second birth (T5 and T10). We present effects separately by sex and parity to allow for heterogenous effects, making for a total of four subsamples. Splitting by parity further ensures that the same individual cannot be both influenced and influencing (i.e., both ego and sibling) in the same statistical model, which could otherwise cause reflection bias (Angrist 2014).

Across subsamples, the reduced form estimates show no significant effect at any conventional level of a sibling having twins on ego's fertility (measured at T5 and T10). The same pertains to the IV estimates. Point estimates tend to be positive; for instance, five years after the sibling's second child was born, first born women on average have 0.075 more children if their sibling also had a third child. Hence, we cannot refute the zero hypothesis that a sibling's family size has no effect on ego's fertility behavior.

When the outcome is measured prior to the sibling's second child is born (T−5), we find no significant effect, corroborating that the instrument is truly (conditonally) exogenous.

Table 4: Effects of sibling's number of children on ego's family size. Twin IV.

	First borns			Second borns		
MEN	(1) RF	(2) IV	(3) OLS	(4) RF	(5) IV	(6) OLS
Ego's number of children at T−5						
Sib twin 2nd birth	0.014			0.009		
	(0.027)			(0.013)		
Sib >2 children		0.024	-0.009		0.016	-0.011**
		(0.048)	(0.006)		(0.023)	(0.003)
Adj. R2	0.231	0.231	0.231	0.222	0.221	0.221
N	62978	62978	62243	76471	76471	75520
Ego's number of children at T0						
Sib twin 2nd birth	0.034			0.004		
	(0.037)			(0.023)		
Sib >2 children		0.060	0.029**		0.007	-0.007
		(0.064)	(0.008)		(0.041)	(0.005)
Adj. R2	0.139	0.139	0.139	0.221	0.221	0.221
N	62978	62978	62243	76471	76471	75520
Ego's number of children at T+5						
Sib twin 2nd birth	0.043			0.003		
	(0.042)			(0.032)		
Sib >2 children		0.075	0.079**		0.005	0.028**
		(0.073)	(0.010)		(0.056)	(0.008)
Adj. R2	0.054	0.055	0.055	0.157	0.157	0.157
N	62978	62978	62243	76471	76471	75520
Ego's number of children at T+10						
Sib twin 2nd birth	0.038			-0.025		
	(0.043)			(0.036)		
Sib >2 children		0.066	0.112**		-0.044	0.072**
		(0.076)	(0.010)		(0.064)	(0.009)
Adj. R2	0.016	0.018	0.019	0.074	0.072	0.074
N	62978	62978	62243	76471	76471	75520
WOMEN	**First borns**			**Second borns**		
	(1) RF	(2) IV	(3) OLS	(4) RF	(5) IV	(6) OLS
Ego's number of children at T−5						
Sib twin 2nd birth	0.016			-0.001		
	(0.032)			(0.018)		
Sib >2 children		0.027	-0.000		-0.001	-0.014**
		(0.057)	(0.008)		(0.031)	(0.004)
Adj. R2	0.221	0.221	0.221	0.279	0.279	0.279
N	58655	58655	57943	72432	72432	71541
Ego's number of children at T0						
Sib twin 2nd birth	-0.021			0.010		
	(0.038)			(0.028)		
Sib >2 children		-0.037	0.051**		0.018	0.005
		(0.068)	(0.009)		(0.048)	(0.007)
Adj. R2	0.085	0.084	0.085	0.239	0.239	0.240
N	58655	58655	57943	72432	72432	71541
Ego's number of children at T+5						
Sib twin 2nd birth	0.020			0.036		
	(0.040)			(0.034)		
Sib >2 children		0.036	0.108**		0.062	0.054**
		(0.071)	(0.009)		(0.058)	(0.008)
Adj. R2	0.013	0.014	0.015	0.133	0.134	0.134
N	58655	58655	57943	72432	72432	71541
Ego's number of children at T+10						
Sib twin 2nd birth	0.014			0.004		
	(0.040)			(0.035)		
Sib >2 children		0.025	0.124**		0.007	0.107**
		(0.071)	(0.009)		(0.061)	(0.008)
Adj. R2	0.002	0.003	0.005	0.044	0.044	0.046
N	58655	58655	57943	72432	72432	71541

Note: The sample is Norwegian firstborn and second-born men and women whose sibling had a second child during the period 1980-1999. Standard errors in parentheses. † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.

Both the IV and RF estimates are relatively imprecisely estimated, and do not differ significantly from the OLS estimates of the correlation in fertility between siblings. Therefore, these results cannot refute that the correlation between sibling's fertility is due to fertility contagion between siblings.

4.3 Exogenous variation from sibship sex composition

We now turn to estimates of obtained from the same sex instrument (Table 5). In contrast to births induced by the twin instrument, a third child born due to a preference for sex mix is by definition intended. Also, while the twinning instrument reduces spacing to zero, the same sex instrument does not. Here, the reduced form estimates capture the effect of the sibling's two first born children being of the same sex.

For most subgroups, the results obtained by the same sex instrument are very similar to those from the twin instrument: Neither the RF nor the IV estimates differ significantly and consistently from zero. One exception emerges: For first born women, we find significant positive effects after five and ten years at the five and ten percent level respectively. However, neither of these point estimates are statistically different from the corresponding point estimates in any of the other subgroups, hence the different results by subgroup should be interpreted with caution. Reassuringly, we find no evidence of significant effects prior to realization of the instrument (at T−5), corroborating validity also for this instrument.

As above, the IV estimates do not differ significantly from the correlation between sibling's fertility behavior as estimated by OLS. Hence, our estimates do not provide evidence against that the association in siblings' fertility behavior

Table 5: Effects of sibling's number of children on ego's family size. Same sex IV.

MEN						
	First borns			**Second borns**		
	(1)	(2)	(3)	(4)	(5)	(6)
	RF	IV	OLS	RF	IV	OLS
Ego's number of children at T−5						
Sib same sex kids	0.004			0.002		
	(0.006)			(0.003)		
Sib >2 children		0.070	-0.009		0.032	-0.011**
		(0.099)	(0.006)		(0.056)	(0.003)
Adj. R2	0.231	0.229	0.231	0.221	0.219	0.221
N	62231	62231	62243	75503	75503	75520
Ego's number of children at T0						
Sib same sex kids	0.009			0.007		
	(0.008)			(0.005)		
Sib >2 children		0.151	0.029**		0.132	-0.007
		(0.134)	(0.008)		(0.100)	(0.005)
Adj. R2	0.139	0.136	0.139	0.221	0.214	0.221
N	62231	62231	62243	75503	75503	75520
Ego's number of children at T+5						
Sib same sex kids	0.014			0.006		
	(0.009)			(0.007)		
Sib >2 children		0.235	0.079**		0.111	0.028**
		(0.151)	(0.010)		(0.138)	(0.008)
Adj. R2	0.054	0.051	0.055	0.157	0.155	0.157
N	62231	62231	62243	75503	75503	75520
Ego's number of children at T+10						
Sib same sex kids	0.014			0.002		
	(0.009)			(0.008)		
Sib >2 children		0.227	0.112**		0.038	0.072**
		(0.157)	(0.010)		(0.158)	(0.009)
Adj. R2	0.017	0.016	0.019	0.074	0.074	0.074
N	62231	62231	62243	75503	75503	75520
WOMEN						
	First borns			**Second borns**		
	(1)	(2)	(3)	(4)	(5)	(6)
	RF	IV	OLS	RF	IV	OLS
Ego's number of children at T−5						
Sib same sex kids	0.003			0.000		
	(0.007)			(0.004)		
Sib >2 children		0.064	-0.000		0.005	-0.014**
		(0.142)	(0.008)		(0.075)	(0.004)
Adj. R2	0.221	0.220	0.221	0.279	0.279	0.279
N	57937	57937	57943	71521	71521	71541
Ego's number of children at T0						
Sib same sex kids	0.006			0.001		
	(0.008)			(0.006)		
Sib >2 children		0.127	0.051**		0.025	0.005
		(0.169)	(0.009)		(0.117)	(0.007)
Adj. R2	0.085	0.084	0.085	0.239	0.239	0.240
N	57937	57937	57943	71521	71521	71541
Ego's number of children at T+5						
Sib same sex kids	0.016†			0.007		
	(0.009)			(0.008)		
Sib >2 children		0.317†	0.108**		0.125	0.054**
		(0.177)	(0.009)		(0.142)	(0.008)
Adj. R2	0.013	0.007	0.015	0.133	0.133	0.134
N	57937	57937	57943	71521	71521	71541
Ego's number of children at T+10						
Sib same sex kids	0.018*			0.004		
	(0.009)			(0.008)		
Sib >2 children		0.362*	0.124**		0.075	0.107**
		(0.178)	(0.009)		(0.148)	(0.008)
Adj. R2	0.002	.	0.005	0.044	0.046	0.046
N	57937	57937	57943	71521	71521	71541

Note: The sample is Norwegian firstborn and second-born men and women whose sibling had a second child during the period 1980-1999. Standard errors in parentheses. † $p < 0.10$,* $p < 0.05$, ** $p < 0.01$.

has a causal mechanism of contagion at its core.

4.4 Subsample analysis

Potentially, non-significant effects in the full sample could mask significant effects in subpopulations where transmission is particularly strong. As theory suggests that similarity fosters transmission (Bernardi and Klaerner 2014), we have estimated the same models including siblings of the same sex only. The overall pattern is consistent across subgroups, with positive but insignificant point estimates, whose confidence intervals also cover the OLS estimates (see Appendix, Tables 6 and 7). Hence, we find no evidence of particularly strong contagion among siblings of the same sex.

Furthermore, it is possible that social contagion is stronger at certain parities: As childless individuals have less information of the consequences of childbearing, they may be more easily influenced by their peers in fertility decisions. Alternatively, a sibling's third birth may convey specific information of life in large families, making it particularly influential on ego's decision of whether to have a third child themselves. To evaluate this, we estimated parity specific models (i.e. models where ego's probability of having at least one or at least three children were the outcome). Again, we found no evidence of effects (results available upon request).

5 Concluding discussion

Recently, the importance of social networks for the transmission of information of the consequences of fertility behavior, has (re)emerged as a topic of demographic interest (Bernardi and Klaerner 2014). While it is indeed good reasons to expect *a priori* that fertility is contagious within networks, there is a striking lack of studies that put this causal hypothesis to a test by obtaining estimates with a plausibly causal interpretation.

We do not find conclusive evidence that siblings have a causal impact on each other's fertility behavior. We utilize two different instrumental variables capturing slightly different fertility events for the sibling: The twin instrument captures an unintended (third) birth with zero spacing to the previous child, while the same sex instrument captures an intended birth, and does not influence spacing in its own right. We also explore whether contagion is stronger between siblings of the same sex, or at specific parities, and find no evidence of this.

Significant point estimates in the subgroup of first born women when using the same sex instrument, albeit not significantly different from the point estimates in the other subgroups, indicate that first born women increase their family size if their (oldest) sibling chooses to have a third child. The finding that women are more perceptive to influence from their social network than are men would be consistent with previous research. The pattern of stronger contagion from a younger to an older sibling than vice versa would on the other hand contrary to our expectation.

In the sociodemographic and sociological literature on contagion, one traditionally allows for (potential) bias in order to gain precision: Correlated fertility behavior within networks can be estimated easily and precisely given available data, and has been demonstrated for a variety of networks in a range of contexts (Balbo and Barban 2014; Lois and Becker 2014; Lyngstad and Prskawetz 2010; Kuziemko 2006; Pink et al. 2014). Such correlated behavior may emerge because individuals in the same network face a similar environment, or because they are similar on relevant unobservable characteristics (Manski 1995). Hence, correlated behavior is not evidence that individuals in the same network causally impact each other's behavior.

The estimates obtained in this paper do not suffer from this kind of bias, as they are obtained from sources of variation that are random, and such exogenous to the network. Based on the results in this study, that we cannot refute that contagion between siblings mainly is due to selection and similarity. In other words, the jury is still out on whether social contagion in this type of network is indeed an important causal mechanism. This should also cast some doubts on causal claims of contagion in other social networks. Our results call for further studies that, rather than providing further descriptions of correlations within networks or theorize on mechanisms that could drive such effects, focus on establishing empirically whether within-network causal effects are plausible.

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Appendix

Table 6: Effects of sibling's number of children on ego's family size. Twin IV. Same sex siblings.

	First borns			Second borns		
MEN						
	(1) RF	(2) IV	(3) OLS	(4) RF	(5) IV	(6) OLS
Ego's number of children at T−5						
Sib twin 2nd birth	0.002			0.005		
	(0.044)			(0.022)		
Sib >2 children		0.003	-0.010		0.009	-0.015**
		(0.078)	(0.010)		(0.039)	(0.005)
Adj. R2	0.205	0.205	0.205	0.227	0.227	0.228
N	28246	28246	27902	35444	35444	34991
Ego's number of children at T0						
Sib twin 2nd birth	-0.006			0.004		
	(0.056)			(0.037)		
Sib >2 children		-0.010	0.048**		0.007	-0.008
		(0.099)	(0.013)		(0.065)	(0.009)
Adj. R2	0.102	0.101	0.102	0.209	0.209	0.209
N	28246	28246	27902	35444	35444	34991
Ego's number of children at T+5						
Sib twin 2nd birth	-0.051			0.010		
	(0.062)			(0.048)		
Sib >2 children		-0.089	0.103**		0.018	0.034**
		(0.109)	(0.014)		(0.086)	(0.012)
Adj. R2	0.029	0.025	0.031	0.129	0.129	0.129
N	28246	28246	27902	35444	35444	34991
Ego's number of children at T+10						
Sib twin 2nd birth	-0.086			-0.002		
	(0.063)			(0.053)		
Sib >2 children		-0.152	0.128**		-0.004	0.087**
		(0.111)	(0.015)		(0.095)	(0.013)
Adj. R2	0.007	-0.003	0.009	0.051	0.050	0.052
N	28246	28246	27902	35444	35444	34991
WOMEN						
	First borns			**Second borns**		
	(1) RF	(2) IV	(3) OLS	(4) RF	(5) IV	(6) OLS
Ego's number of children at T−5						
Sib twin 2nd birth	0.062			0.015		
	(0.041)			(0.021)		
Sib >2 children		0.109	0.003		0.026	-0.010*
		(0.072)	(0.010)		(0.035)	(0.005)
Adj. R2	0.223	0.221	0.222	0.239	0.238	0.238
N	32555	32555	32150	39864	39864	39374
Ego's number of children at T0						
Sib twin 2nd birth	0.023			0.049		
	(0.050)			(0.035)		
Sib >2 children		0.040	0.066**		0.082	0.006
		(0.088)	(0.012)		(0.059)	(0.008)
Adj. R2	0.089	0.090	0.089	0.219	0.217	0.219
N	32555	32555	32150	39864	39864	39374
Ego's number of children at T+5						
Sib twin 2nd birth	0.032			0.057		
	(0.053)			(0.045)		
Sib >2 children		0.057	0.130**		0.096	0.050**
		(0.093)	(0.013)		(0.075)	(0.011)
Adj. R2	0.014	0.016	0.017	0.130	0.130	0.129
N	32555	32555	32150	39864	39864	39374
Ego's number of children at T+10						
Sib twin 2nd birth	0.018			0.017		
	(0.054)			(0.047)		
Sib >2 children		0.032	0.149**		0.029	0.117**
		(0.094)	(0.013)		(0.080)	(0.011)
Adj. R2	0.002	0.003	0.006	0.046	0.047	0.049
N	32555	32555	32150	39864	39864	39374

Note: The sample is Norwegian firstborn and second-born men and women whose sibling had a second child during the period 1980-1999, and whose oldest sibling is of the same sex as themselves. Standard errors in parentheses. † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.

Table 7: Effects of sibling's number of children on ego's family size. SSC IV. Same sex siblings.

MEN	**First borns**			**Second borns**		
	(1) RF	(2) IV	(3) OLS	(4) RF	(5) IV	(6) OLS
Ego's number of children at T−5						
Sib same sex kids	-0.002			0.001		
	(0.010)			(0.005)		
Sib >2 children		-0.044	-0.010		0.018	-0.015**
		(0.180)	(0.010)		(0.118)	(0.005)
Adj. R2	0.205	0.204	0.205	0.227	0.227	0.228
N	27894	27894	27902	34985	34985	34991
Ego's number of children at T0						
Sib same sex kids	0.001			0.010		
	(0.013)			(0.008)		
Sib >2 children		0.024	0.048**		0.242	-0.008
		(0.229)	(0.013)		(0.202)	(0.009)
Adj. R2	0.102	0.102	0.102	0.209	0.191	0.209
N	27894	27894	27902	34985	34985	34991
Ego's number of children at T+5						
Sib same sex kids	0.010			0.014		
	(0.014)			(0.011)		
Sib >2 children		0.184	0.103**		0.339	0.034**
		(0.251)	(0.014)		(0.266)	(0.012)
Adj. R2	0.029	0.030	0.031	0.129	0.111	0.129
N	27894	27894	27902	34985	34985	34991
Ego's number of children at T+10						
Sib same sex kids	0.009			0.015		
	(0.014)			(0.012)		
Sib >2 children		0.165	0.128**		0.360	0.087**
		(0.257)	(0.015)		(0.294)	(0.013)
Adj. R2	0.007	0.009	0.009	0.051	0.039	0.052
N	27894	27894	27902	34985	34985	34991

WOMEN	**First borns**			**Second borns**		
	(1) RF	(2) IV	(3) OLS	(4) RF	(5) IV	(6) OLS
Ego's number of children at T−5						
Sib same sex kids	-0.001			-0.003		
	(0.009)			(0.005)		
Sib >2 children		-0.012	0.003		-0.068	-0.010*
		(0.188)	(0.010)		(0.090)	(0.005)
Adj. R2	0.222	0.222	0.222	0.238	0.235	0.238
N	32148	32148	32150	39364	39364	39374
Ego's number of children at T0						
Sib same sex kids	0.001			-0.002		
	(0.011)			(0.008)		
Sib >2 children		0.027	0.066**		-0.038	0.006
		(0.231)	(0.012)		(0.153)	(0.008)
Adj. R2	0.089	0.089	0.089	0.218	0.218	0.219
N	32148	32148	32150	39364	39364	39374
Ego's number of children at T+5						
Sib same sex kids	0.006			0.001		
	(0.012)			(0.010)		
Sib >2 children		0.128	0.130**		0.022	0.050**
		(0.243)	(0.013)		(0.194)	(0.011)
Adj. R2	0.014	0.017	0.017	0.129	0.129	0.129
N	32148	32148	32150	39364	39364	39374
Ego's number of children at T+10						
Sib same sex kids	0.010			0.004		
	(0.012)			(0.011)		
Sib >2 children		0.210	0.149**		0.079	0.117**
		(0.245)	(0.013)		(0.205)	(0.011)
Adj. R2	0.002	0.005	0.006	0.046	0.048	0.049
N	32148	32148	32150	39364	39364	39374

Note: The sample is Norwegian firstborn and second-born men and women whose sibling had a second child during the period 1980-1999, and whose oldest sibling is of the same sex as themselves. Standard errors in parentheses. † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.

Statistics Norway

Postal address:
PO Box 8131 Dept
NO-0033 Oslo

Office address:
Akersveien 26, Oslo
Oterveien 23, Kongsvinger

E-mail: ssb@ssb.no
Internet: www.ssb.no
Telephone: + 47 62 88 50 00

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Statistics Norway

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