Family size and Children's Educational Attainment:

Identification from the Extended Family

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Abstract:

Previous research has used twin births and sibling sex composition to provide quasi-experimental variation in family size to estimate the causal effect of family size on children's educational outcomes. Using data from the Wisconsin Longitudinal Study, we extend previous research by analyzing the educational attainment of first cousins who come from the same extended family but from different nuclear families. We exploit variation in nuclear family size within the extended family to estimate the effect of family size on educational attainment net of a rich set of controls and extended family fixed effects. Moreover, we use variation in in-married spouses' fecundity and family size preferences (measured via their number of siblings) to provide quasi-experimental variation in family size within the extended family. Similar to previous research, our analyses provide little support for the hypothesis that family size has a negative effect on educational attainment.

Introduction

Theories of intergenerational transmissions in economics and demography suggest that a trade-off exists between family size and the amount of resources (e.g., time and money) parents invest in each of their children. In particular, it has been argued that parental investments which influence human capital accumulation are especially vulnerable to this trade-off. As such, theory predicts that family size has a negative effect on children's long-term educational outcomes (Becker 1960; Blake 1981; Downey 1995; Gibbs et al. 2016).

There is abundant descriptive evidence of a negative correlation between family size and children's educational outcomes (measured by, for example, test scores and educational attainment), which seems to confirm the "quantity-quality tradeoff" (Steelman et al. 2002). However, because family size may be correlated with other, unobservable aspects of family background that may also affect children's educational outcomes, it remains unclear if the negative correlation reported in previous research has a causal interpretation. For example, parents who strongly value personal consumption may desire fewer children, but simultaneously transfer these values those children they have to gain more education in order fulfill their own eventual consumption desires. To address this limitation, a recent literature has exploited "natural" experiments, such as second-parity twin births and sibling sex composition, to identify the causal effect of family size on children's educational outcomes with the use of instrumental variables (IVs). This literature argues that a twin birth represents a quasi-experimental shock to family size that is otherwise unrelated to children's outcomes. Other research that uses sibling sex composition argues that since the probability of having a boy or girl in each successive birth is nearly equal, the sex composition of the sibship is randomly assigned. If parents have a preference for a certain sex composition, for example having one boy and one girl, then the sex composition of the existing sibship might affect the likelihood that parents have more children. Results from research that uses twin births and sibling sex composition to provide quasi-experimental variation in family size are mixed, but most research suggests that family size has no causal effect on children's educational outcomes, at least not in developed countries.

In this paper we propose an alternative approach to addressing the endogenous nature of family size in a model of children's educational attainment. Using the Wisconsin Longitudinal Study (WLS), we exploit the fact that nuclear families are nested within extended families to study the educational attainment of first cousins. These first cousins are members of the same extended family (linked via parents who are siblings), but experience varying degrees of exposure to siblings. Our research design has two complimentary components.

First, we exploit variation in nuclear family size *within* extended families to estimate the effect of family size on first cousins' educational attainment by controlling for extended family fixed effects (FE). This approach controls for omitted characteristics of the extended family (for example, shared propensity for health outcomes, abilities, preferences, and socioeconomic characteristics) that are correlated with family size and with children's educational attainment. Some research has used a FE design to analyze how increases in family size over time within families affects academic achievement (Guo and VanWey 1999; Rodgers et al. 2001; Sandberg and Rafail 2014), and we extend this research by focusing on the extended (rather than the nuclear) family and on final educational attainment (rather than on achievement).

Second, we extend the extended family FE design with an IV design that exploits differences across nuclear families in in-married spouses' fecundity and family size preferences, proxied by their own number of siblings, to aid in the identification of the causal effect of family size (Jæger 2008; Silles 2010). This IV is motivated by a consistent body of research showing that fertility is positively correlated across generations (Murphy 1999) due to an intergenerational transmission of fecundity, family socialization, and exposure to a larger family (Axinn et al. 1994;

Kosova et al. 2010; Rodgers et al. 2001). As a consequence, the number of siblings that in-married spouses have should be predictive of how many children they eventually have. The validity of our IV hinges on the assumption that in-married spouses' number of siblings does not have any effect on their children's educational outcomes other than via family size. Although we cannot formally test this assumption, we argue that the combination of rich data (which include observable family characteristics such as income, education, and parental IQ) and a research design which controls out extended family FEs makes this assumption credible.

The proposed research design is an important contribution to the literature as it addresses some of the inferential and interpretational limitations in existing approaches. First, research that uses twin births and sibling sex composition as IVs for family size relies on assumptions that may not be credible. Although low in absolute numbers, the frequency of twin births has increased substantially over time due to improvements in reproductive technologies (such as infertility treatment) and increasing maternal age at first birth (Kissin et al. 2005; Vohr et al. 2009; Smith 2011). Since, in most countries, access to reproductive technologies depends on income, and more highly educated women tend to be older at first birth (which increases the probability of a twin birth), twin births, in fact, may not be exogenous to children's outcomes (at least not in recent history). With regard to sibling sex composition, even though the sex composition of the sibship is likely random, this natural experiment is only informative about the likelihood of having a third or higher order birth. Since the mean total fertility rate in most OECD counties is currently around 1.7, it then follows that, like the twin experiment, the sex composition experiment applies only to a selected share of the population. In addition, it may be difficult to interpret estimates of the effect of family size in research using sex composition because preferences for certain sexes vary across cultures and indeed may even vary within the same population. For example, parents in Western countries seem to prefer having children of both sexes, while parents in some Asian countries seem to prefer boys over girls (Andersson et al. 2006; Freedman et al. 1960; Arnold and Zhaoxiang 1986; Clark 2000). An advantage of our design is that it incorporates variation across the entire distribution of family size in the WLS (rather than just in a selective population). Moreover, the IV that we propose uses variation in in-married spouses' number of siblings across all extended families in the WLS, leading to greater statistical power in our analyses as well as greater generalizability.

The results from the empirical analysis show that family size is negatively correlated with children's educational attainment. However, after controlling for observable individual and family characteristics and extended family FEs we find that family size has no effect on educational attainment. This result persists when, in addition, we instrument differences in family size within extended families by differences in in-married spouses' number of siblings. Our IV estimates are close to zero and not statistically significant which, similar with other research, suggests that the negative correlation between family size and children's educational attainment is attributable to factors other than family size.

Theoretical Background

This section presents our theoretical framework. We draw on theory from demography and economics to argue that family size should have a negative effect on children's educational outcomes. We also review designs and results from empirical research that has attempted to address the endogenous nature of family size with regard to children's educational outcomes.

The Resource Dilution Model

The *Resource Dilution Model* (RDM) argues that parents have a finite pool of resources, some of which will be divided equally among their children, some of which will be reserved for the parents themselves, and some that will be shared by all members of the family (Downey 1995; Gibbs et al. 2016). These resources take the form of income/wealth, time, and social capital, all of which can be used to influence children's environments (e.g., quality of housing, exposure to cultural objects), opportunities (e.g. going to private versus public schools), and the amount of personal attention they receive from their parents (Blake 1981). Parental resources may be used to benefit their children's development in several ways. On the one hand, they may be used to purchase "public goods" (i.e., items or experiences that can be shared by all), such as housing, books, or a computer, that can benefit the entire family. On the other hand, they may also be used to invest in their children's well-being in ways that can only benefit specific individuals within the household, such as by paying for college tuition or music lessons. It is typically assumed that parental resources are constant (at least in the long term) and that parents do not exhibit preferential or compensatory behavior when assigning resources to their children. As such, the RDM leads one to expect that each additional child in a family will necessarily lead to a reduction in the per capita investments children will receive from their parents, which, *ceteris paribus*, should lead to worse later-life outcomes among children with more siblings. Larger families will be therefore be particularly detrimental for those outcomes that are highly dependent on parental investments that cannot be shared, such as those concerning formal education.

The Quantity-Quality Trade-Off

The RDM does not include an explicit behavioral framework for analyzing how parents decide on how many children to have and how many of their resources to invest in each child. Parents' decisions are crucial to understand, as they underlie the fundamental empirical challenge associated with addressing the endogeneity of family size in a model of parental investments in their children.

The "Quantity-Quantity Trade-Off" model (QQM) argues that couples make fertility decisions much as they make decisions about their consumption of market goods (e.g., cars, clothing, real estate, etc.; Becker 1960; Becker and Lewis 1973; Becker and Tomes 1976). That is, they jointly decide on both how many children they will have and what "quality" (i.e., level of investment) those children will be. Within the QQM couples are considered to be utility maximizing agents who derive satisfaction from the consumption of a combination of children and market goods. As such, the demand for both of these will increase with couples' level of income. However, couples cannot have unlimited amounts of goods and children, as their choice set is constrained by a household budget (Becker 1993). In a constrained budget couples are tasked with selecting the optimal combination of market goods, quantity of children, and quality of those children. In other words, they must simultaneously decide both how many children they will have and how much they want to invest into each one.

It is precisely this relationship between quantity and quality that can generate misleading results in empirical research concerned with determining the causal effect of family size on children's outcomes. According to the RDM, the direction of causality is rather explicit; the addition of a child will reduce the existing resources available to all children in a family. The QQM, on the other hand, makes it quite clear that one could expect to find a negative correlation between family size and educational attainment because parents consciously decided that they would invest in quantity over quality given their budget constraint. This does not necessarily mean, however, that it is family size *per se* that reduces average child quality. In order to make that claim it is necessary to adopt an empirical strategy that can identify a change in either quality or quantity that occurs *independently* of the other in order to estimate the causal relationship between the two. At the present, there are generally only a limited number of approaches that have been widely adopted for accomplishing this task and it is the goal of the present study to review these and offer a new approach that holds several advantages over the existing approaches.

Literature Review

In this section we review existing research and, based on this review, present our own research design. Table 1 summarizes the research designs and main findings from previous research seeking to identify the causal effect of family size on children's educational outcomes (Steelman et al. 2002 review earlier descriptive research). Previous research has used one of two research designs: instrumental variables (IV) or fixed effects (FE).

– TABLE 1 HERE –

Most research has used an IV design to provide exogenous or "quasi-experimental" variation in family size, and twin births and sibship sex composition have been the preferred IVs. In addition to these, some research has also used policy reforms to the same end. Examples include: changes in China's family planning policy (Argys and Averett 2015; Liu 2014; Qian 2009), municipal contraceptive bans in the Philippines (Dumas and Lefranc 2013), physical distance to family planning centers (Dang and Rogers 2016), variation in reproductive capacity as measured by, for example, sub(fecundity) (Bougma et al. 2015; Jæger 2008; Silles 2010) and miscarriages (Maralani 2008), and variation in contraceptive technologies (Rosenzweig and Schultz 1987). As shown in Table 1, results from studies using IVs are mixed, but most research, particularly that focusing on developed countries, finds no effect of family size on children's educational outcomes.

In addition to IVs, other research has used variation in family size within families to analyze its effects on children's educational outcomes (Guo and VanWey 1999; Rodgers et al.

2001; Sandberg and Rafail 2014). This body of research uses a FE design to control for omitted aspects of family background that affect both family size and children's educational outcomes. The identifying assumption is that, conditional on FEs and a rich set of observed family characteristics, the estimated effect of family size on children's educational outcomes is causal. In line with research using IVs, studies using a FE approach typically have found no effect of family size on children's educational outcomes.

Research Design

Our research design is based on two complimentary strategies and illustrated in Figure 1 using the Wisconsin Longitudinal Study (WLS). The first strategy uses variation in family size between two nuclear families nested within the same extended family to identify the effect of family size on children's educational attainment. This strategy estimates the causal effect net of extended family FEs. The second component extends this design by also exploiting factors that affect nuclear family size but not children's educational attainment, in this case in-married spouses' fecundity and family size preferences (proxied by their own number of siblings), to provide an IV for differences in family size between nuclear families within the same extended family.

Figure 1 is based on the data structure in the WLS. The focal respondent (and generation), the WLS Graduate, is labeled A. The WLS also includes a randomly selected (older or younger) sibling of A, labeled B (the sibling respondent). Moreover, it includes the spouses of A and B, labelled A' and B' (as explained below, we restrict the analysis to intact families). Nuclear families AA' and BB' are the second generation in the WLS. There is also information on the parents of sibling pair A and B, labeled AB_{-1} (where $_{-1}$ refers to the previous generation), and on the parents of A and B's spouses, labeled A'_{-1} and B'_{-1}, respectively. Finally, the WLS includes information on all children of A and B, i.e., the third generation and labeled $A_{+1,n}$ and $B_{+1,n}$, respectively (where subscript *n* refers to child number). It then follows that in the WLS children of A and B are first cousins who belong to the same extended family (linked via A and B) but to separate nuclear families (AA' and BB'). We observe these first cousins' educational attainment (years of completed schooling), total number of siblings, and many characteristics of the nuclear family in which they grew up.

– FIGURE 1 HERE –

Extended Family Design

Within a regression framework, our baseline (linear) model specification is:

$$y_{ijk} = \alpha + \beta_1 f_{jk} + \beta_2 \mathbf{z}_{jk} + \beta_3 \mathbf{x}_{ijk} + e_k + c_{jk} + \varepsilon_{ijk}, \qquad (1)$$

where y_{ijk} is the educational attainment of child *i* (*i = 1,…,n*) belonging to nuclear family *j* (*j = 1,…,n*) and extended family *k* (*k = 1,…,n*). Using the terminology from Figure 1, children are the third generation in the WLS, i.e., $A_{+1,n}$ and $B_{+1,n}$, parents in nuclear families AA' and BB' are the second generation, and grandparents AB_{-1}, A'_{-1}, and B'_{-1} are the first generation. The observed explanatory variables in the model include family size *f* (our main explanatory variable), other nuclear family characteristics captured in the vector **z**, and individual child characteristics captured in the vector **x**. In this model *f* and **z** vary across nuclear and extended families (hence subscripts *j* and *k*), while **x** varies across individuals, nuclear families, and extended families (hence subscripts *i*, *j* and *k*). The model also includes an effect specific to each extended family, e_k, each nuclear family c_{jk}, and a random error term ε_{ijk}.

The first part of our research design consists in controlling out the effect specific to each extended family. This effect captures the influence of all omitted aspects of the extended family that affect first cousins' educational attainment (for example health, abilities, preferences, and unobservable socioeconomic characteristics, such as inheritance expectations). To do this, we rearrange Equation 1 by subtracting extended family means for all variables and, using a difference operator, we get:

$$\Delta y_{ijk} = \beta_1 \Delta f_{jk} + \beta_2 \Delta \mathbf{z} + \beta_3 \Delta \mathbf{x}_{ijk} + c_{jk} + \Delta \varepsilon_{ijk}. \tag{2}$$

Equation 2 shows a Within-Family Fixed Effect FE (WF-FE) model in which the effect of family size on children's educational attainment is identified from variation in family size between nuclear families from the same extended family. For example, it may be that, within the same extended family, nuclear family AA' has two children, while BB' has three, which yields a difference of one. This model, which is our baseline model specification, cancels out the extended family FE e_k and controls for observable individual and family characteristics captured in **z** and **x**.

Exogenous Variation in Family Size

Our WF-FE design identifies the effect of family size on children's educational attainment net of observed family and individual characteristics and extended family FEs. We extend this design by exploiting variation in nuclear family size within the extended family which we argue affects family size but which has no direct effect on children's educational attainment. Imagine an extended family with two sisters (A and B in Figure 1). These sisters marry different men (A' and B') and eventually become mothers. Observable differences in sisters' family size may arise from differences in their (and their husbands') fecundity, family size preferences, and from random factors. In this paper we propose to use in-married spouses' number of siblings as an empirical proxy for variation in fecundity and family size preferences that these spouses bring into the family comprised of A and B. Moreover, we argue that in-married spouses who have more siblings have higher fecundity and preferences for larger families. We motivate this hypothesis based on several pieces of research

Existing research documents a positive correlation in completed fertility across generations (Dahlberg 2013; Murphy 1999); individuals who grew up with more siblings tend to have more children. The intergenerational correlation in completed fertility is due to a combination of genetic and environmental factors. Genetic factors may influence, for example, reproductive health that is transmitted from parents to children (Kosova et al. 2010; Rodgers et al. 2001). Environmental factors include family socialization (parents transmitting positive values and norms about the desirability of a larger family to their children), being exposed to a larger family (which might lead older siblings to become caregivers for younger siblings), and contemporaneous influences from other siblings' reproduction (Axinn et al. 1994; Duncan et al. 1965; Lyngstad and Prskawetz 2010; Régnier-Loilier 2006). Consequently, there is a compelling argument as to why in-married spouses' number of siblings should be positively correlated with their own family size. If this is the case in our WLS data, in-married spouses' number of siblings is a relevant IV for nuclear family size (we discuss validity below).

To formalize this idea, we extend the WF-FE model by adding an IV component that treats family size as endogenous to children's educational attainment

$$\Delta y_{ijk} = \beta_1 \Delta \hat{f}_{jk} + \beta_2 \Delta \mathbf{z} + \beta_3 \Delta \mathbf{x}_{ijk} + c_{jk} + \Delta \varepsilon_{ijk}, \qquad (3)$$

$$\Delta f_{jk} = \delta_1 \Delta I_{jk} + \delta_2 \Delta \mathbf{z} + \delta_3 \Delta \mathbf{x}_{ijk} + c_{jk} + \Delta \xi_{ijk}. \qquad (4)$$

In this model, Equation 3 (the WF-FE model for differences in children's educational attainment) is the second stage regression, while Equation 4 (the model for differences in family size) is the first stage regression. In the first stage regression we regress differences in family size across nuclear families (denoted Δf) on differences in in-married spouses' number of siblings (denoted ΔI) and the **z** and **x** variables described above. In the second stage regression we use the predicted differences in nuclear family size from the first stage regression, denoted $\Delta\hat{f}_{jk}$, to estimate the effect of family size on children's educational attainment, β_1 (Angrist and Pischke 2009). In this model, our estimate of β_1 is identified from the variation in in-married spouses' number of siblings that exists within all extended families in the WLS rather than, as is the case with twin births and sibling sex composition, from variation that exists in small or select subgroups in the data.

In order to be a valid IV, in-married spouses' number of siblings must not have any direct effect on children's educational attainment. We believe that this assumption is credible for two reasons. First, we control for a wide range of observable family characteristics that might be correlated both with in-married spouses' number of siblings and with their children's educational attainment, including parents' education, SES, income, and IQ. Second, our design controls out extended family FEs which capture the influence of omitted factors that are correlated with family size and with children's educational attainment. In particular, the design controls for omitted factors that lead siblings A and B to have similar mating preferences (due to shared family socialization) and similar socioeconomic characteristics (due to shared family resources). Consequently, although we cannot rule out that in-married spouses' number of siblings might have a direct effect on children's educational attainment, we argue that our research design significantly reduces this risk.

Since our IV model is based on nested data (first cousins are nested both in nuclear and extended families), the number of observations in the first stage regression is based on the number of nuclear families in the WLS (captures by subscript *j*) while the number of observations in the second stage regression is based on the total number of children (captured by subscript *i*). All reported test statistics and standard errors adjust for clustering of respondents within these different levels of nesting.

Finally, in order to compare our results with those from previous research that uses twin births and sibship sex composition as IVs for family size, we also construct empirical indicators of twin births and sibship sex composition and report results from analyses using these as IVs for family size (see Table 3).[1]

Data and Variables

We use data from the Wisconsin Longitudinal Study (WLS). The WLS is a longitudinal study of a random sample of 10,317 individuals who graduated from Wisconsin High Schools in 1957. It contains rich information on, among other things, socioeconomic background, education, income, and family formation. The WLS graduates (A in Figure 1) have been interviewed in 1957, 1964, 1975, 1992, 2004, and 2011. In 1977 the WLS added a sample of 2,000 randomly selected siblings of the WLS graduates (one sibling for each WLS graduate), and in 1993 the sibling sample was expanded to include a randomly selected (older or younger) sibling of all WLS graduates with at least one sibling (B in Figure 1). Sibling respondents have been re-interviewed in 2005 and 2011, and in 2004 and 2005 the spouses of the WLS graduate and the sibling respondents were also interviewed (A' and B' in Figure 1). In the 1992/1993 and 2004/2005 waves WLS graduates and

[1] We note that in the IV models in which we use twin births and sibship sex composition as IVs for family size (see Table 3) we rely on cross-sectional (rather than within extended family) variation in twin births and sex composition. This is because twin births are rare events in the first place, and if we were to only use variation in twin births within extended families we would not have sufficient variation in data to credibly identify our IV models.

sibling respondents provided information on all of their children (i.e., $A_{+1,n}, B_{+1,n}$), for example on their educational attainment.

The primary sample in our analysis includes the children of the WLS graduates and the sibling respondents. In terms of family relatedness, this sample includes siblings (linked via nuclear families AA' and BB') and first cousins (linked via parents who are siblings). We restrict the sample to children whose parents have been married only once in order to ensure that we have information on the spouses who are the parents of the children whose educational attainment we study. We further restrict the sample to include children who were at least 25 years old when information on their educational attainment was collected. We use this restriction to be reasonably sure that children have completed their education (Warren and Hauser 1997 and Jæger 2012 apply similar restrictions). Our analysis sample consists of 18,133 children nested in 6,182 nuclear families and 5,093 extended families.

Dependent Variable

Our dependent variable is children's educational attainment, measured by years of completed schooling.

Explanatory variables

Family size is our main explanatory variable. This variable measures total number of children in each nuclear family AA' and BB', respectively, and it includes biological as well as adopted, step, and foster children. Mean family size in the WLS is 3.7 (SD = 1.6).

We also include a range of family and individual control variables (i.e., the **z** and **x** variables discussed above). Family control variables include mother and father's education (years of completed schooling), total family income in 1976 in $1,000s[2], father's socioeconomic status (SES, measured by Duncan SEI), and the WLS graduate or sibling respondent's IQ at around age 18 (captured by their score on the Hemnon-Nelson IQ test). The *individual* control variables include sex (dummy for women), birth order, and year of birth.[3]

Instrumental Variables

Our proposed IV for differences in nuclear family size within the extended family is the in-married spouse's number of siblings. Operationally, this variable measures spouse A' and B''s number of siblings (ever born), as reported by these spouses in separate spousal surveys. In supplementary analyses we also distinguish between in-married spouses' number of younger and older siblings, and we have constructed variables that capture this information.

In addition to our main IVs, we also replicate the twin and sex composition IVs that have been used in previous research. Following Black et al. (2010) we capture twin births with a dummy variable indicating if the second birth included multiple births. Operationally, this variable is derived from information on whether the second- and third born child in families AA' and BB' was born in the same year and to the same biological mother (and in a different year than the firstborn child). We measure the sibling sex composition with a dummy variable indicating if the first- and second-born child has the same sex.

[2] We impute missing information on total family income using data on the WLS graduate and sibling's personal income in 1974 and household income in 1992.

[3] The WLS includes some information on the socioeconomic characteristics of the first generation in the WLS (i.e., AB_{-1}, A'_{-1}, and B'_{-1}). Unfortunately, although there is rich information on AB_{-1} (education, income, SES, etc.), and some information on A'_{-1}, the only available information on B'_{-1} is family size. Given that most of our substantive analyses rely exclusively on variation within the extended family, the only variable in the first generation that we can (and do) use is family size.

Results

We present the empirical findings in four subsections. First, we present results from baseline Ordinary Least Squares (OLS) regressions of children's educational attainment on family size and controls. Results from these models are comparable to those presented in previous descriptive research. Second, we present results from WF-FE models which control for observed individual and family characteristics and extended family FEs. Third, we present results from IV models in which we use in-married spouses' number of siblings as an IV for differences in family size across nuclear families. Finally, we compare our IV estimates with those obtained using an alternative coding of our IV that distinguishes number of younger and older siblings and those obtained using the twin birth and sibship sex composition IVs.

Baseline OLS Results

Table 3 summarizes our empirical results. The first two columns show results from baseline OLS regressions of children's years of completed schooling on family size and individual and family controls. In the model without controls we find a negative effect of family size on educational attainment, with each additional sibling estimated to reduce education by about 0.15 years of schooling ($p < 0.001$). This result is similar to those found by previous descriptive studies (Jæger 2008; Steelman et al. 2002). In the second column we add the control variables, which significantly reduces our estimate of the negative effect of family size ($\tilde{\beta}_1 = -0.032$, $p < 0.05$). This finding suggests that much of the correlation between family size and educational attainment is simply due to socioeconomic characteristics (education, income, SES etc.).

– TABLE 3 HERE –

Within Extended Family Results

Columns three and four summarize results from WF-FE models. Results from these models are interpreted in the same way as the OLS models, with the difference that the effect of family size is identified exclusively from variation in nuclear family size within extended families. In the baseline WF-FE model without controls we find a negative and statistically significant effect of family size on educational attainment ($\tilde{\beta}_1$ = -0.076, $p < 0.05$). In this model the coefficient on family size is about half the size of the coefficient in the corresponding baseline OLS model, which suggests that omitted aspects of the extended family that are correlated with family size account for about half of the negative effect of family size in the OLS model. Thus, unobserved characteristics of the extended family make the relationship appear more strongly negative than it is. When we also include control variables (sex, birth order, year of birth, parents' education, father's SES, family income, and IQ) the coefficient on family size is estimated to be close to zero and is no longer statistically significant. Substantively, our analyses suggest that, in contrast with the RDH and QQM, family size does not have any negative causal effect on children's educational attainment. This finding adds to existing research that has used FE and IV by employing a new research design but reaching the same substantive conclusion regarding the effect of family size.

Instrumenting Family Size

Results from the previous sections suggest that we can completely explain the baseline negative effect of family size on children's educational attainment by including observable characteristics and controlling for extended family FEs. However, we cannot be sure that our WF-FE models fully address the possibility that the effect of family size indirectly captures omitted aspects of family background that are correlated with, but substantively different from, family size. We now address this possibility by, in addition to including observable characteristics and extended family FEs, we instrument differences in family size within extended families with differences in the in-married spouse's number of siblings.

Table 3 summarizes results from different specifications of the IV model. The upper part of the table summarizes results from the second stage regression while the lower part summarizes results from the first stage regression. We begin with the first stage regression. Here, and as hypothesized, we find that the in-married spouse's number of siblings has a positive effect on nuclear family size. This positive effect might arise from an intergenerational transmission of fecundity, from family socialization or exposure to a larger family. An increase in the in-married spouse's number of siblings by one is estimated to increase own family size by 0.031 ($p < 0.001$). Moreover, we find that the value of the F-test for the excluded instrument is 11.83, i.e., above the conventional threshold of 10 for a statistically relevant IV (Staiger and Stock 1997). Together, results from the first stage regression suggest that the in-married spouse's number of siblings is a relevant IV for family size which predicts family size in the expected direction.[4] In the second stage regression we use the predicted value of family size from the first stage regression to estimate the causal effect of family size on educational attainment. The upper part of Table 3 shows that our estimate of the effect of family size in the second stage regression is close to zero ($\tilde{\beta}_1$ = -0.019) and not statistically significant. Once again, we find no evidence that family size affects children's educational attainment, a result which contradicts the RDM and QQM, but which is in line with other research that addresses the endogeneity of family size.

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[4] In IV models in which we do not include extended family fixed effects the estimated effect of in-married spouse's number of siblings on own family size in the first stage regression is 0.063 ($p < 0.001$; F = 78.58). This result suggests that the extended family fixed effects are effective in picking up omitted aspects of family background, for example those leading to assortative mating.

Until this point, one limitation of our IV design has been that we cannot distinguish the different mechanisms that drive the positive effect of the in-married spouse's number of siblings on family size in the first stage. All we know is that growing up with more siblings is associated with having more children. As explained earlier, this effect may arise from an intergenerational transmission of fecundity, family socialization, or exposure to a larger family. We now propose an approach for distinguishing the effect of socialization from that of exposure to a larger family. Direct socialization of values and norms regarding a desired family size affects all children in a family. By contrast, exposure to a larger family depends on one's position in the sibship, with children born earlier being more exposed to younger siblings than those born later. Research suggests that children who have a greater number of younger siblings (but not those who have older) are more likely to take on the role as caregivers for younger siblings, such as providing practical help, comfort, and surrogate parenting (Gass et al. 2007). This role might lead them to develop a preference for a larger family (since they are less intimidated by the responsibilities of parenthood). If true, this mechanism would entail that the in-married spouse's number of *younger* siblings is more strongly associated with own family size than their number of *older* siblings (Murphy and Knudsen 2002). Table 3 shows summarizes results from IV models in which – instead of the in-married spouse's total number of siblings – we use the in-married spouse's number of respectively younger and older siblings as IVs for family size. The table shows that number of younger siblings has a strong positive effect on family size ($\tilde{\delta}_1 = 0.102$, $p < 0.001$; F = 43.34), while number of older siblings has no effect ($\tilde{\delta}_1 = -0.001$, $p > 0.05$; F = 0.00). Consequently, while we are unable to adjudicate between the fecundity and socialization mechanisms (which arguably affects all siblings equally), our results provide support for the interpretation that role adoption (rather than family socialization) is the environmental mechanism that drives the positive effect of number of siblings on family size.[5] This finding is useful for understanding the mechanisms through our IV operates and for assessing the validity of the IV (since adopting a role as caregiver would not be expected to have any direct effect on children's educational attainment).

Finally, Table 3 shows results from IV models in which we use twin births and sibship sex composition as IVs for family size. The reason for presenting these IV results is to compare them with our results which use a different identification strategy but the same data set. The first stage regressions show that having twins in the first birth is estimated to increase family size by around one child ($\tilde{\delta}_1$ = 1.039, $p < 0.001$; F = 23.25), while having two children of the same sex (in two first births) does not increase the probability of having a third child ($\tilde{\delta}_1$ = 0.040, $p > 0.05$; F = 1.21)[6]. Results from the second stage regressions show that family size has no effect on educational attainment in either IV specification. These results are similar to previous research that has used twin births and sex composition as IVs for family size.

In terms of interpretation, we note that the point estimates of the effect of family size in our IV models that use in-married spouses' number of siblings as an IV for family size are

[5] The stronger effect of number of younger siblings in the alternative specification of the IV might also capture an effect of the in-married spouse's birth order (since in-married spouses with many younger siblings are more likely to have a lower birth order than those with many older siblings). The bivariate correlation between the in-married spouse's number of younger siblings and birth order is -0.18 (p < 0.001) and thus fairly low. Controlling for the in-married spouse's birth order in the IV model in which we use number of younger siblings as an IV for family size does not change our estimates of the effect of number of younger siblings (results available upon request). Murphy and Knudsen (2002) find no effect of birth order on own fertility.

[6] Using the same WLS data and a similar setup, De Haan (2010) reports a highly significant first stage using the sibship sex composition instrument. In her paper, De Haan restricts the sample to include only children from families with two to five children. Using this restriction, we obtain first stage results similar to the ones of De Haan ($\tilde{\delta}_1$ = 0.098, $p <$ 0.001; F = 13.10).

numerically smaller than those obtained using the twin birth and sibship sex composition IVs (although none are statistically significant). An IV estimate should be interpreted as a Local Average Treatment Effect (LATE), i.e., an estimate of the causal effect that applies to those who comply with the treatment induced by the IV (Imbens and Angrist 1994). The twin birth and sibship sex composition IVs identify LATEs that pertain to particular subgroups in a population, in this case those who change their fertility behavior in response to a twin birth and those who adjust it in light of the sexes of existing children. We argue that the LATE identified by our IV applies to a larger population because it is based on variation in number of siblings across all extended families in the WLS (and all in-married spouses contribute to this variation). Consequently, our IV estimate of the effect of family size on children's educational attainment is arguably a better approximation of the population effect than those presented in previous research that uses IVs. We return to this issue in the discussion.

Conclusion

This paper was motivated by theory arguing that family size should have a negative causal effect on children's educational outcomes and by empirical research which suggests that this might not to be the case. It adds to existing empirical research by proposing a new research design that combines observational variation in family size across nuclear families from the same extended family (which controls out extended family FEs) and arguably exogenous variation in nuclear family size arising from differences in in-married spouses' fecundity and family size preferences (which is used as an IV for family size). The new research design has two benefits. First, it combines the FE and IV approaches that have been used separately in previous research to provide a more robust estimate of the causal effect of family size on educational attainment. Second, the proposed IV identifies a LATE that generalizes to a larger population than those identified in previous research.

The empirical results show that, after controlling for omitted characteristics of the extended family that are correlated with family size and with first cousins' educational attainment (for example, shared health, abilities, preferences, and socioeconomic characteristics), family size has no causal effect on first cousins' educational attainment. When, in addition, we instrument differences in family size across nuclear families from the same extended family, we find that in-married spouses' number of (younger) siblings has a positive effect on family size (an effect which we interpret as arising from the adoption of a caregiver role, which leads to a preference for a larger family), but also that family size has no effect on educational attainment. Overall, our results accord with previous evidence that the negative correlation between family size and educational attainment that has been observed in descriptive research does not capture a causal relationship. We now provide some input for future research and address some limitations and opportunities in our research design.

First, our results and those from previous research suggest that, even in light of strong theoretical expectations, it is difficult to identify a causal effect of family size on children's educational outcomes. Objections can be raised against the validity of previous attempts at isolating exogenous variation in family size. Twin births are challenged by the rise of infertility treatment and, more generally, the fact that older (and often better educated) mothers are more likely to have twins. The sibling sex composition is random, but this IV yields exogenous variation only in the probability of having a third birth, a parity transition that has become increasingly rare among cohorts born in the twentieth century. Moreover, research using policy reforms as IVs, for example changes in China's one child policy, face the challenge that these reforms might also affect children's educational outcomes via other channels (for example, changes in cohort sizes due to policy reforms might lead to smaller/bigger class sizes and make it easier/more difficult to gain access to university). While we cannot formally test the validity of the IV that we propose, we are reassured by the fact that our research design includes extended family FEs (which control out assortative mating and shared family characteristics that might affect children's educational attainment) and our finding that the mechanism through which the IV likely operates (role adoption, as captured by number of younger siblings) is unlikely to be directly related to children's educational attainment.

Second, even if a valid IV can be found, the causal effect of family size identified by an IV may be difficult to interpret. Findings from research that has used sibling sex composition as an IV for family size illustrate this point. This research reports no consistent findings, probably due to differences across studies in the underlying (and unknown) subpopulations who comply with the treatment. As a consequence, LATE estimates of the effect of family size are heterogeneous and cannot easily be compared. In this paper we also identify a LATE, but we argue that since the variation induced by our IV comes from the entire distribution of in-married spouses' number of (younger) siblings, this LATE has greater generalizability than those used in previous research (in terms of external validity). We should note though that the LATE identified in this study applies only to intact WLS families who change their fertility behavior in response to the treatment (number of siblings the in-married spouse has).

Assuming that the extended family FEs control adequately for assortative mating, we may think of the estimate from the first stage regression as capturing the average increase in family size that arises from the WLS graduate/sibling respondent marrying a person who has one additional sibling. We may examine who are the "compliers" that are most likely to respond to the treatment, and we have some information on the in-married spouse's characteristics, for example their sex. We have run the first stage regression in the IV model with an interaction effect between number of younger siblings (IV) and the in-married spouse's sex (dummy for female). This analysis is informative about whether nuclear family size increases more as a function of the in-married spouse's number of siblings if the in-married spouse is a woman compared to if he is a man. Results show that family size increases more if the in-married spouse is a woman, which supports the idea that the effect of the treatment may differ across groups (unfortunately, we do not have information on the cultural or social background of in-married spouses which would enable us to carry out a more detailed analysis).

In addition to examining if (and how) our IV works differently across subpopulations, we could also expand the extended family design to control in a more comprehensive way for omitted family characteristics. In particular, we could exploit information about the genetic relatedness between the WLS graduate and the sibling respondent to accomplish this goal. For example, in some families the WLS graduate and sibling respondent are monozygotic (MZ) twins (and in others one sibling is adopted while the other is a full sibling). In cases in which A and B are MZ twins, our WF-FE model would control for a much more comprehensive set of omitted genetic aspects of family background than is currently the case (since MZ twins are genetic clones at birth and share their family environment). Similarly, if the either the WLS graduate or the sibling respondent is adopted, the WF-FE model would control for fewer omitted aspects of family background (since the WLS graduate and sibling respondents share environments but not genes). Both analyses would be informative in their own right and, in the case of MZ twins, would strengthen the validity of the IV design since controlling in a more comprehensive manner for omitted family background characteristics reduce the risk that the IV picks up the effect of these characteristics. Unfortunately, there are too few MZ twins (N ~ 40) and adoptees (N ~ 60) among the WLS graduates and sibling respondents to implement this genetically informed WF-FE design. However, this design would be possible with other datasets, for example the comprehensive register data available in the Nordic countries. In this regard, our paper showcases a research design that can be extended in future research.

Finally, our results, and those from existing research, provide little support for the RDH and QQM: there is no evidence that, on average, coming from a larger family leads to lower educational attainment. It may be time to rethink the RDH and QQM and, in particular, to expand these models to take into account institutional and cultural differences in the ways in which family size may (not) affect children's outcomes. Gibbs, Workman and Downey (2016) propose a conditional RDH in which the negative effect of family size differs across communities and religious groups. Our research design could be used to test this type of explanation because, given available information on in-married spouses, we could test if the effect of number of siblings on own family size depends on these spouses' cultural and social characteristics.

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Figure 1. Family Structure in the WLS

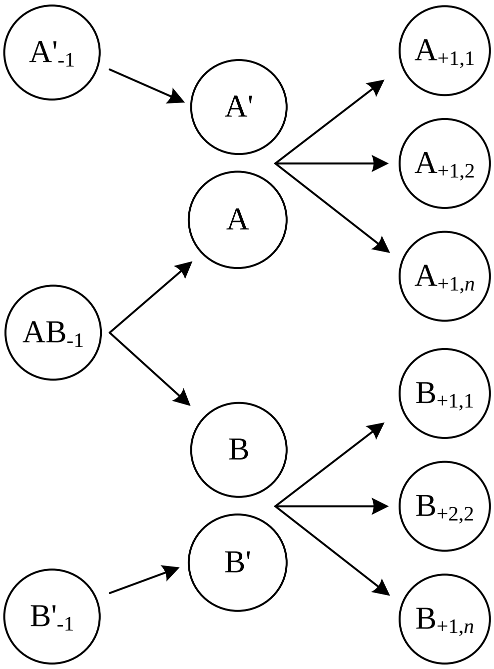

Table 1. Results from Research on Family Size and Children's Educational Outcomes

Study	Outcome	Effect of Family Size	Identification Strategy	Country
Rosenzweig and Schultz (1987)	Years of schooling	Negative	IV (contraceptive use)	Malaysia
Guo and VanWey (1999)	Cognitive ability (test scores)	No effect	Within-child and within-family FE	US
Rodgers et al. (2001)	IQ	No effect	Within-family FE	US
Black et al. (2005)	Years of schooling	No effect	IV (Twin births, sex composition)	Norway
Cáceres-Delpiano (2006)	Educational attainment	No effect	IV (Twin births)	US
Conley and Glauber (2006)	Grade repetition	Firstborns: No effect; Second borns: Positive	IV (Sex composition)	US
Baez (2008)	Years of schooling	Negative	IV (Sex composition)	Colombia
Jæger (2008)	Years of schooling	Negative	IV (mothers' and fathers' family size and age at first birth)	US
Lee (2008)	Household expenditure on education	Negative (non-linear)	IV (Sex composition)[a]	South Korea
Li et al. (2008)	Educational level	Rural: Negative Urban: No effect	IV (Twin births)	China
Maralani (2008)	Years of schooling	No effect	IV (Women's reports of miscarriages)	Indonesia
Dayioglu et al. (2009)	School enrollment	No effect	IV (Twin births)	Turkey
Rosenzweig and Zhang (2009)	Years of schooling	Negative	IV (Twin births) and FE	China
Qian (2009)	School enrollment	Positive	IV (China's family planning policy)	China
Angrist et al. (2010)	Years of schooling	No effect	IV (Sex composition and twin births)	Israel
Black et al (2010)	IQ	Sex composition: No effect Twin births: Negative	IV (Sex composition and twin births)	Norway
De Haan (2010)	Years of schooling	No effect	IV (Sex composition and twin births)	US
Ferrari and Zuanna (2010)	Attainment of university degree	Italy: No effect; France: Positive	IV (Sex composition)	France and Italy
Silles (2010)	Cognitive ability (test scores)	Negative	IV (mothers' family size, time between marriage and first birth	Great Britain

			and sex composition)	
Åslund and Grönqvist (2010)	Grade Point Average, years of schooling, university enrollment	No effect	IV (Twin births)	Sweden
Frenette (2011)	Reading score and school attendance	Reading score: No effect School attendance: Negative	IV (Twin births)	Canada
Kang (2011)	Private tutoring expenses	Boys: No effect Girls: Negative	IV(Sex composition)[a]	South Korea
Marteleto and de Souza (2012)	Years of schooling	2+ children: No effect 3+ children: Positive Change over time: 1977-1990 positive, later: no effect	IV (Twin births)	Brazil
Ponczek and Souza (2012)	Years of schooling, school progression	Boys: No effect Girls: Negative	IV (Twin births)	Brazil
Bagger et al. (2013)	Years of schooling	Negative	IV (Twin births) + family FE	Denmark
Dumas and Lefranc (2013)	Grade repetition	Negative	DID (municipal contraceptive ban)	Philippines
Fitzsimons and Malde (2014)	Years of schooling	No effect	IV (Sex composition)[a]	Mexico
Liu (2014)	Years of schooling	No effect	IV (China's family planning policy)	China
Sandberg and Rafail (2014)	Cognitive ability (test scores)	No effect	Within-child FE	US
Argys and Averett (2015)	Years of schooling	Negative	DID (migrants flows + China's family planning policy)	US
Bougma et al. (2015)	Years of schooling	Negative	IV (sub fecundity)	Burkina Faso
Kugler and Kumar (2015)	Years of schooling	Negative	IV (Sex composition)[a]	India
Dang and Rogers (2016)	Years of schooling, tutoring	Years of schooling: No effect Tutoring: negative	IV (distance to family planning center)	Vietnam

Notes: IV = Instrumental Variable; FE = Fixed effect; DID = Difference in Difference, [a] Sex composition = Preference for boys (rather than preference for mixed-sex sibships)

Table 2. Descriptive Statistics

	Mean	SD	N
Years of education	14.33	2.08	18,133
Family size	3.69	1.63	18,133
Controls:			
Birth order	2.32	1.36	18,133
Sex	0.49	0.50	18,131
Age (in 2004)	38.17	5.33	18,078
Father's education	13.75	2.73	16,761
Mother's education	12.98	1.82	16,982
Father SES	49.77	25.46	17,745
Family income	18.90	11.25	17,274
IQ of WLS graduate/sibling respondent	101.96	14.58	17,362
Instrumental variables:			
Spouse's number of siblings	4.41	2.71	15,576
Spouse's number of younger siblings	1.99	1.96	11,502
Spouse's number of older siblings	1.58	1.97	11,592
Twin birth (second)	0.01	0.09	18,133
Sex composition (two boys/two girls)	0.50	0.50	18,133

Table 3. Summary of Regressions of Family Size on Children's Educational Attainment

Design	Between Family (OLS)		Within Extended Family (WF-FE)		WF-FE + IV			Replication IV	
	Baseline	W. Controls	Baseline	W. Controls	Spouse: No. sibs	Spouse: No. younger sibs	Spouse: No. older sibs	Twin birth[b]	Sibling sex composition
Family size	-0.148 (0.016)***	-0.032 (0.015)*	-0.076 (0.026)*	0.028 (0.026)	-0.019 (0.068)	0.019 (0.127)	0.038 (0.125)	0.189 (0.296)	1.991 (2.346)
Controls[a]	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Extended family FE	No	No	Yes	Yes	Yes	Yes	Yes	No	No
N	15,037	15,037	15,037	15,037	14,527	10,306	10,394	4,625	4,625
<u>First stage IV:</u>									
Spouse's number of siblings					0.031 (0.009)***	0.102 (0.015)***	-0.021 (0.016)		
Twin birth								1.039 (0.215)***	
Sex composition (two boys/two girls)									0.040 (0.036)
F-test for excluded instruments					11.83	43.34	0.00	23.25	1.21
N (first stage)					4,904	3,495	3,518	4,625	4,625

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, [a] Controls: *Child*: Birth order, sex, and age. *Parents*: Father's education, mother's education, father's SES, family income, and IQ, [b] Sample includes firstborns in families with two or more children. Standard errors in OLS and IV models are adjusted for clustering of children within nuclear and extended families.