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Sibship size and educational attainment. A joint test of the Confluence Model and the Resource Dilution Hypothesis

Mads Meier Jæger*

The Danish National Centre for Social Research, Research Group on Social Policy and Welfare Services, Herluf Trolles Gade 11, DK-1052 Copenhagen K., Denmark

Abstract

Studies on family background often explain the negative effect of sibship size on educational attainment by one of two theories: the Confluence Model (CM) or the Resource Dilution Hypothesis (RDH). However, as both theories – for substantively different reasons – predict that sibship size should have a negative effect on educational attainment most studies cannot distinguish empirically between the CM and the RDH. In this paper, I use the different theoretical predictions in the CM and RDH on the role of cognitive ability as a partial or complete mediator of the effect of sibship size to distinguish the two theories and to identify a unique RDH effect on educational attainment. Using sibling data from the Wisconsin Longitudinal Study (WLS) and a random effect Instrumental Variable model I find that, in addition to a negative effect on cognitive ability, sibship size also has a strong negative effect on educational attainment which is uniquely explained by the RDH.

Keywords

Family background; Educational attainment; Sibship size; Confluence Model; Resource Dilution Hypothesis

1. Introduction

A common finding in the literature on family background and educational success is that sibship size has a negative effect on children's intellectual and educational outcomes (e.g., Cicirelli, 1978; Ernst & Angst, 1983; Heer, 1985; Steelman, 1985; Steelman, Powell, Werum, & Carter, 2002). Two theoretical models are often used to explain this phenomenon: the Confluence Model (CM) and the Resource Dilution Hypothesis (RDH). The CM, originating in psychology, argues that the primary channel through which sibship size has a negative effect on children's educational success is through the creation of an inferior intellectual environment in families with many children (see Zajonc, 1976, 1983; Zajonc & Markus, 1975). In contrast, the RDH, originating in sociology and demography, argues that the increasing dilution in large families of parents' resources: economic, social, emotional, interpersonal, etc. is the reason why children with many siblings obtain less education than children with few siblings (e.g., Anastasi, 1956; Blake, 1981, 1989; Downey, 1995, 2001).

There is an ongoing debate in the literature on whether the CM or the RDH offers the more correct interpretation of the empirical regularity that sibship size is negatively correlated with children's intellectual and educational outcomes (e.g., Downey, 2001; Ernst & Angst, 1983; Retherford & Sewell, 1991; Steelman, 1985; Steelman et al., 2002). The major problem in this debate is that at face value findings from most empirical studies are equally consistent with the predictions from both the CM and the RDH. There is a large literature documenting that sibship size is negatively correlated with children's intellectual ability (for reviews see, e.g., Cicirelli, 1978; Heer, 1985; Steelman, 1985; Steelman et al., 2002). Furthermore, many studies also find that sibship size is negatively correlated with final educational attainment (e.g., Blake, 1989; Conley, 2000; Featherman & Hauser, 1978; Plug & Vijverberg, 2003; Sandefur, Meier, & Campbell, 2006; Steelman et al., 2002). Finally, some studies attempt to explain what the negative effect of sibship size on educational outcomes captures by controlling for other factors such as birth spacing and sibship sex composition (e.g., Powell & Steelman, 1990, 1993), parents' economic investments in children (e.g., Powell & Steelman, 1989, 1995), and parents' interpersonal resources and communication with children (e.g., Cheung & Andersen, 2003; Downey, 1995; Powell & Steelman, 1993). However, these studies do not seek to determine if the CM or the RDH explains the observed negative relationship between sibship size and children's educational outcomes.

But is it possible to distinguish empirically between the CM and the RDH? In this paper, I propose to use a key theoretical difference between the CM and the RDH with respect to the role of cognitive ability as a partial or complete mediator of the sibship size effect to distinguish between the two theories. According to the CM, low cognitive ability caused by being raised in an intellectually poor environment is the principal reason why children from large families obtain less education than children from small families. By contrast, the RDH offers a more comprehensive explanation in which strains on several types of parental resources, and not just strains affecting cognitive ability, is the reason why sibship size has a negative effect on educational attainment. This difference between the two theories has important empirical implications because, according to the CM, the negative effect of sibship size runs *exclusively* through cognitive ability whereas, according to the RDH, there should be an *additional* negative effect of sibship size on educational attainment. Because this additional negative effect of sibship size is uniquely explained by the RDH it becomes possible to distinguish between the two theories.

In addition to proposing a way of distinguishing between the CM and the RDH, this paper also deals with unobserved family characteristics that affect educational outcomes. Though rarely explicated, both the CM and the RDH pertain to the *environmental* and not the genetic or physiological effects on educational success of coming from a large family. There is some evidence that parents with low IQ tend to have many children (e.g., Grotevant, Scarr, & Weinberg, 1977) and that certain physiological or health problems are more prevalent in large than in small families (e.g., Belmont & Marolla, 1973). If such relationships exist the effect of sibship size on children's educational outcomes might reflect genetic or physiological influences rather than the environmental effects hypothesized by the CM and the RDH. To deal with this potential problem I use sibling data which allows me to control for unobserved genetic and environmental characteristics shared by siblings (e.g., Lindert, 1977; Olneck & Bills, 1979; Sandefur & Wells, 1999; Sieben, Huinink, & de Graaf, 2001).

Using an Instrumental Variable random effect model and sibling data from the Wisconsin Longitudinal Study my findings are, first, that sibship size has a significant negative effect on cognitive ability, and second, in addition to its effect on cognitive ability, sibship size also has a direct negative effect on educational attainment. My analysis then shows that there is a direct effect of sibship size on educational attainment which is uniquely explained

by the RDH and, furthermore, that this direct effect is stronger than the effect of sibship size on cognitive ability.

The paper proceeds as follows. In the next section, I present the theoretical background. Section 3 describes the data and variables, and Section 4 develops the empirical framework. Section 5 presents the results of the empirical analysis, and in Section 6 I consider some avenues for future research.

2. Theoretical background

This section presents the two major explanations of the negative relationship between sibship size and children's educational success: The Confluence Model and the Resource Dilution Hypothesis. Furthermore, the section discusses several important differences between the two theories that I use to distinguish the empirical implications of each theory.

2.1. The Confluence Model

The Confluence Model (CM) was proposed by Zajonc and colleagues (Zajonc, 1976, 1983; Zajonc & Markus, 1975). The core idea in the CM is that a child's intellectual ability is shaped by the total intellectual level in the family of origin. This total intellectual level is calculated as the average of the absolute intellectual level of all family members. Parents have much higher intellectual skills than children, and the arrival of a new child with low initial intellectual skills in the family decreases the family's total intellectual level. Consequently, families with many children provide an intellectually "immature" environment since "... larger families will be associated with lower intellectual levels because the larger the family, the larger is the proportion of individuals with low absolute intelligence" (Zajonc & Markus, 1975, p. 77).

According to the CM, several other sibship characteristics are also important in determining children's intellectual ability. First, birth order effects are hypothesized to be significant because firstborns are particularly advantaged by not having other siblings who decrease the family's total intellectual level. Similarly, lastborns are hypothesized to be particularly disadvantaged because the intellectual level in the family is lowest when they are born into the family. Only children are assumed to have a lower "firstborn advantage" because, unlike firstborns with younger siblings, they do not derive intellectual gains from acting as "teachers" to their younger siblings.

Finally, in the CM birth spacing is hypothesized to be very important with respect to children's intellectual ability. The reason why is that closely spaced siblings decrease the family's intellectual level relatively more than widely spaced sibships in which older siblings are more intellectually mature. Consequently, being born into a family with a long rather than a short interval between siblings is hypothesized to benefit children's intellectual ability (Zajonc, 1983; Zajonc & Markus, 1975).

2.2. The Resource Dilution Hypothesis

The Resource Dilution Hypothesis (RDH) concerns the relationship between family resources, parental resource allocations, and children's outcomes (e.g., Anastasi, 1956; Blake, 1981, 1985, 1989; Downey, 1995, 2001; Steelman et al., 2002). The RDH begins from the observation that all types of parental resources and inputs: Economic, time, social, and interpersonal are intrinsically limited. Consequently, it follows from the RDH that when the size of the family increases the amount of parental resources and inputs available to each child in the family decreases. The fewer parental resources to each child in large families compared to in small families are then hypothesized to lead to poorer child outcomes. Parents' economic and material resources (such as money for college) which cannot be

shared by siblings dilute quickly when the number of children in the family grows, whereas cultural, social, and interpersonal resources need not dilute equally quickly (Downey, 1995; Steelman et al., 2002).

2.3. Theoretical differences between the CM and the RDH

It is important to analyze how the CM and the RDH differ and how differences between the two theories can be used to derive testable implications of each theory. The CM is sometimes regarded as subsumable under the RDH. However, this is not correct as the RDH and CM differ with respect to the theoretical roles they ascribe to the three fundamental sibship characteristics: sibship size, birth spacing, and birth order. In this section, I consider two issues: the different theoretical implications of the CM and the RDH for educational attainment and the different roles the two theories ascribe to the three fundamental sibship characteristics.

The CM and RDH have different theoretical implications for educational attainment. The CM explains educational attainment through the impact of sibship size, birth order, and birth spacing on children's cognitive ability. In contrast, the RDH is a more general hypothesis of the relationship between sibship size and different types of parental resources which extends beyond cognitive ability (for example, educational attainment, occupational status, income, etc.). This theoretical difference is described by Downey (2001, p. 497):

“... whereas the confluence model offers no explanation for an effect of sibship size on educational attainment apart from intellectual skills, the resource dilution model explains that although some parental resources influence intellectual skills, other parental resources (e.g., money saved for college) affect attainment directly.”

Consequently, in the CM the effect of sibship size on educational attainment runs exclusively through children's cognitive ability. It follows from the RDH that there should be an *additional* effect of sibship size on educational attainment originating in parental resources and inputs that are unrelated to children's cognitive ability. This theoretical difference between the CM and the RDH is important because it allows for a direct test of the two channels through which sibship size affects educational attainment: an indirect effect through cognitive ability and a direct effect on educational attainment. In other words, while the negative effect of sibship size on cognitive ability may be explained theoretically by both the CM and RDH, any additional *direct* effect of sibship size on educational attainment can only be explained by the RDH.

In addition to these different implications, the CM and the RDH also differ with respect to the theoretical role they assign to the different sibship characteristics (sibship size, birth spacing, and birth order).¹ It is important to highlight these differences, first, to explicate how the two theories differ and, second, to determine how the two theories can be distinguished empirically. The theoretical role of sibship size, birth spacing, and birth order in the CM and the RDH is summarized in Table 1.

First, sibship size is a key theoretical dimension in both the CM and the RDH. Both theories hypothesize (although for different reasons) that sibship size has a negative effect on children's cognitive and educational outcomes.

¹Some studies also treat the sex composition of the sibship as a separate sibship characteristic (e.g., Butcher & Case, 1994; Conley, 2000; Hauser & Kuo, 1998; Kaestner, 1997). This characteristic is important in developing countries and countries in which parents have cultural preferences for certain sexes. The sex composition of the sibship is, however, probably not of great importance in the US context and is not considered further in this paper.

Second, birth spacing is important in the CM but does not have any theoretical role in the RDH. In the CM, longer spacing between siblings generally leads to better cognitive outcomes. However, holding constant sibship size and birth order, the CM also predicts that the impact of birth spacing differs depending on whether the spacing relates to the next *older* or *younger* sibling. Since older children have higher IQ and thereby increase the family's IQ level, the presence of an older sibling is beneficial to younger children's cognitive ability. Accordingly, the longer is the spacing to the next older sibling the higher is children's cognitive ability. By contrast, net of sibship size and birth order effects it follows from the CM that longer spacing to the next *younger* sibling should have a negative effect on a child's cognitive ability because the presence of a much younger sibling decreases the family's IQ level. I address these different birth spacing effects in the empirical analysis.

Some proponents of the RDH have argued that birth spacing affects educational outcomes because closely spaced births exert particular strains on parental resources (e.g., Powell & Steelman, 1990). However, this is not likely because this argument requires, first, that such an effect exists *over and above* the effect of sibship size (i.e., the negative effect on parental resources of having more rather than fewer children), and second, that this negative effect is not reasonably counterbalanced by economies-of-scale advantages of having similarly aged children who consume similar commodities (clothes, food, toys, etc.) and demand similar types of parental inputs (attention, care, etc.). Third, in addition this argument also implies that closely spaced children should be more resource demanding than children spaced further apart.² Below I review the existing empirical evidence of a direct effect of birth spacing on educational attainment.

Third, unlike in the CM, birth order does not have a role in the RDH. Some advocates of the RDH argue that birth order might matter because firstborns are particularly advantaged in terms of parental attention and engagement. On the other hand, later born siblings are hypothesized to receive more financial resources because older parents typically have higher incomes (Mare & Tzeng, 1989; Powell & Steelman, 1990, 1993, 1995). However, these proposed birth order effects mostly build on empirical observations rather than the RDH itself. Furthermore, in a recent review of the empirical evidence on birth order effects Steelman et al. (2002, p. 257) conclude: "This mélange of differential birth order effects on parental resources produces no consistent pattern of effects of birth order on intellectual performance or educational attainment."

I include measures of all three sibship characteristics in the empirical analysis. Sibship size is of particular interest in the analysis, but also birth spacing plays a significant role because I use the spacing between older and younger siblings as an instrumental variable for cognitive ability. Birth order is included as a control variable.

2.4. Hypotheses

Based on my review of the CM and the RDH I propose two hypotheses of the effect of sibship size on cognitive ability and educational attainment:

²Evidence from the US suggests that the total annual cost of a child (age 0–18) does not depend on its age (although the relative weight of different cost components: food, transportation, health care, etc. change with the age of the child) (Lino, 2005). Possibly, in the US birth spacing might be relevant with respect to the costs of education, for example when having several children going through college at the same time. However, many families save for college throughout children's childhood and thus distribute this financial burden over time (e.g., Hart, 1990). Second, scholarships and grants exist which alleviate the financial costs of college education. Third, public policies subsidize college education in low-income families either through direct funding or tax incentives. In the Wisconsin Longitudinal Study, a sample of the parents of the main respondents were asked (when respondents were around 17–18 years old) if they did not want the respondents to pursue more schooling because it was too expensive for the family. Less than 1 percent of parents agreed with this statement.

- A. According to both the CM and the RDH sibship size should have a negative effect on children's cognitive ability.
- B. The RDH predicts that sibship size should have an *additional* negative effect on educational attainment net of the effect running through cognitive ability. This effect is attributable to RDH factors that are uncorrelated with children's cognitive ability. According to the CM such an effect should not exist.

The empirical analysis tests these two hypotheses.

3. Data and variables

3.1. Data

I use data from the Wisconsin Longitudinal Study (WLS). The WLS is a longitudinal study of a random sample of 10 317 men and women who graduated from Wisconsin high schools in 1957. Interviews with the primary respondents or their parents have been carried out in 1957, 1964, 1975, 1992/1993, and 2004. Response rates have remained remarkably high throughout the study period, with around 90 percent of the sample being re-interviewed in the 1964 and 1975 waves from which most of the variables used in this paper come (see Hauser & Sewell, 1985; Sewell & Hauser, 1980; Warren, Hauser, & Sheridan, 2002).

The WLS has three major advantages over other large-scale data sets in this context. First, the WLS has extensive information not only on the primary WLS respondents but also, for a random sample of the primary respondents, on a selected sibling. Second, in addition to the usual socioeconomic background variables and measures of educational and occupational attainment, the WLS includes a standardized measure of cognitive ability for both the primary WLS respondent and his or her sibling. Information on cognitive ability is crucial in this paper. Third, unlike most other data sets, the WLS includes information both on sibship size, birth order, and birth spacing. Together, these features make the WLS ideal for my analysis.

In this paper, I analyze a sub-sample of WLS respondents for whom information on final educational attainment is available for both the primary respondents and their randomly selected siblings. This restriction yields a gross sample of 5192 respondent–sibling pairs which, when merged into a joint data set, has a total of 10 384 observations (i.e., 5192 respondent and 5192 sibling observations). In the analysis that follows I use the term “respondent” to refer to both the primary WLS respondents and their siblings. This is done because I do not need to distinguish between the primary WLS respondents and their siblings in the empirical analysis (the two-level structure in the data is used to identify unobserved family effects, see Section 4). The variables in the analysis are presented below.

While the WLS data is well suited for my research it also has several limitations. First, being comprised of high school graduates only, the WLS has an under representation of respondents from lower socioeconomic strata who did not attend high school or who dropped out. This means that the WLS graduates are more homogeneous in terms of socioeconomic characteristics compared to similar US cohorts. Second, there are only very few African American, Hispanic, or Asian respondents in the WLS. This limitation means that race differences in educational attainment cannot be analyzed with the WLS. However, the WLS is largely representative of the white US population who graduated from high school. Finally, the WLS sample consists of families with relatively many children (because all families have at least two children).

3.2. Variables

Table 2 presents summary statistics for the variables in the analysis.

The main dependent variable is years of schooling completed by the respondents. This variable is top-coded at 20 years of schooling. The second dependent variable is the respondent's score on the Hemnon–Nelson Test of General Mental Ability (see Warren et al., 2002 pp. 440–441 for more information on this test). The Hemnon–Nelson test is a standardized measure of general cognitive ability and was carried out when the respondents were around 16–17 years old; i.e., prior to them pursuing higher education.

The main explanatory variable is *sibship size*. This variable counts the respondent's total number of brothers and sisters (number of siblings for the main respondent also includes his or her sibling in the data set and vice versa). *Birth order* is measured by the ordinal position in the sibship. Specifically, I include dummy variables for first- and lastborns. *Birth spacing* is measured by two variables: (1) the number of years between the respondent and the next *older* sibling and (2) the number of years between the respondent and the next *younger* sibling.

I also include a range of socioeconomic background and demographic controls. First, I control for family income. The income variable is defined as the natural logarithm of total parental income in 1957 measured in hundreds of US dollars. Second, I include father and mother's education measured in years of completed schooling (again, both variables are top-coded at 20 years). Third, I control for father's socioeconomic status (SES) in 1957 measured by Duncan's (1961) scale of Occupational Prestige. Fourth, I include a dummy variable equal to 1 for respondents who grew up in a "broken" family, i.e., in a family where both biological parents were not present throughout childhood. Fifth, I control for upbringing in a rural environment with a dummy variable for respondents whose fathers were farmers. Finally, I include a dummy variable to control for the respondent's sex (with 1 = female and 0 = male).

4. Methods

The idea behind the analysis is to distinguish between two different effects of sibship size on educational attainment: (1) an indirect effect running through cognitive ability and (2) an additional direct effect on educational attainment. Both the CM and RDH hypothesize that the indirect effect exists. According to the CM, this effect captures how large sibships drain the family's intellectually climate which in turn lowers children's cognitive ability and, as a consequence, their educational attainment. According to the RDH, the indirect effect captures how large sibships drain parents' resources which lead to low cognitive performance in children and subsequent low educational attainment. However, the additional direct effect of sibship size on educational attainment is unique to the RDH and captures how resource dilution mechanisms that are unrelated to children's cognitive development (for example, college costs) affect educational attainment. The aim of the empirical analysis is to simultaneously estimate both the indirect and the direct effect of sibship size on educational attainment. In particular, I am interested in determining if the direct "RDH effect" of sibship size on educational attainment, conditional on the indirect effect, is statistically significant.

My statistical framework which simultaneously estimates both the indirect and direct effects of sibship size can be formulated as a linear random effect Instrumental Variable (RE-IV) model (e.g., Wooldridge, 2002, 2005). The two simultaneous models in the RE-IV framework: a main model in which educational attainment is the dependent variable and a second model in which cognitive ability is the dependent variable, are described in more detail below and illustrated in Fig. 1.

The RE-IV consists of two simultaneous regression equations. Sibship size appears as an explanatory variable in both equations. The first so-called “second stage” regression estimates the direct “RDH effect” of sibship size on educational attainment. The second so-called “first stage” regression estimates the indirect effect of sibship size on educational attainment running through cognitive ability. Effects from the second stage regression are shown with solid line arrows in Fig. 1 and effects from the first stage regression are shown with dotted line arrows.

The main “second stage” regression model is

$$y_{ij} = \alpha + \beta_1 s_{ij} + \delta c_{ij} + \gamma_1' x_{ij} + f_j + \varepsilon_{1ij}, \quad (1)$$

where the dependent variable y_{ij} is years of completed schooling by respondent i ($i = 1, \dots, N$) from family j ($j = 1, \dots, J$). In this model s is sibship size and has regression coefficient β_1 . The coefficient β_1 is the direct effect of sibship size on educational attainment and, following Hypothesis B, I expect this effect to be statistically significant and negative. Furthermore, c is cognitive ability with coefficient δ , and x is the vector of socioeconomic background, sibship, and demographic variables with coefficient vector γ_1' .

The error structure in the model is comprised from the two last components in Eq. (1). Since the data consists of sibling pairs it is possible to identify f_j which captures time-invariant unobserved family characteristics, genetic and environmental, that affect educational attainment. I apply standard random effect assumptions for this unobserved family effect, i.e., that it follows a normal distribution ($f_j \sim N(0, \sigma_f^2)$) and is uncorrelated with the observed variables in the model.³ Finally, ε_{1ij} is a stochastic error term assumed to be normally distributed with constant variance, $\varepsilon_{1ij} \sim N(0, \sigma_{\varepsilon_1}^2)$.

The “first stage” regression in which cognitive ability is the dependent variable is

$$c_{ij} = \alpha + \beta_2 s_{ij} + \gamma_2' x_{ij} + \eta z_{ij} + \varepsilon_{2ij}. \quad (2)$$

Here c is cognitive ability, s is sibship size, and β_2 measures the effect of sibship size on cognitive ability. Consequently, β_2 tests Hypothesis A stating that sibship size should have a negative effect on cognitive ability. Furthermore, the x 's are the socioeconomic background, sibship, and demographic variables with coefficient vector γ_2' , and ε_{2ij} is a normally distributed error term with constant variance.

To simultaneously identify both Eqs. (1) and (2) I need an “instrumental” variable z which appears only in Eq. (2). I use birth spacing as an instrument for cognitive ability. Using birth spacing as an instrument for cognitive ability implies that, controlling for all other sibship and socioeconomic variables and unobserved family effects, I assume that birth spacing to the next older and younger sibling does not have any effect on educational attainment other than that going through cognitive ability. Below I discuss the theoretical and empirical motivation for treating birth spacing as an instrument for cognitive ability, and later in the empirical analysis I show that, conditional on the other sibship and socioeconomic variables

³A sibling fixed effect model would have preferable to the random effect model used here because the fixed effect model allows for a correlation between observed and unobserved variables (Wooldridge, 2002, 2005). However, the sibling fixed effect model only identifies the effect of explanatory variables that vary within families (for example siblings' cognitive ability) and not variables that only vary between families. Since sibship size does not vary within families the fixed effect model is not feasible here.

and unobserved family heterogeneity, there is strong evidence that birth spacing only affects respondents' educational attainment through their cognitive ability.

4.1. Birth spacing as an instrument for cognitive ability

The validity of birth spacing as an instrument for cognitive ability depends on whether it is reasonable to assume that, net of other sibship and socioeconomic variables, there is no effect of birth spacing to the next older and younger sibling on educational attainment other than that going through cognitive ability (in Fig. 1 this assumption is illustrated by the fact that there is no arrow from birth spacing to educational attainment). There are some theoretical arguments to support this assumption. In the CM, birth spacing is important for educational attainment only through its impact on cognitive ability. Longer spacing to the next older sibling leads to higher cognitive ability while longer spacing to the next younger sibling leads to lower cognitive ability. In the words of Powell and Steelman (1993, p. 368): "If the confluence theory explains the impact of spacing on educational attainment, then ability should be the key factor mediating the impact of spacing". By contrast, birth spacing has no theoretical role in the RDH. Consequently, there are theoretical reasons to believe that birth spacing only affects educational attainment through cognitive ability.

Furthermore, there is little empirical evidence from existing studies that birth spacing has an independent effect on educational attainment net of cognitive ability and socioeconomic background. In a recent review paper Steelman et al. (2002, pp. 244–245) argue: "There ... seems to be an 'educational benefit of being spaced out' ...: that is, close spacing of siblings has been shown to negatively affect educational success". However, upon closer inspection this conclusion is not warranted. Steelman et al. base their conclusion by citing Dandes and Dow (1969), Galbraith (1982), Kidwell (1981), and Powell and Steelman (1990, 1993). All of these studies except Powell and Steelman (1993) use intelligence measures, cognitive tests scores, or school grades as the outcome variable and, with the exception of Powell and Steelman (1993), none of the studies relate birth spacing to final educational attainment. Consequently, the studies cited by Steelman et al. (2002) do not support the conclusion that there is a direct link between birth spacing and educational attainment.⁴ Results from my empirical analysis provide the same impression.

5. Results

This section presents the results of the empirical analysis. I estimate three models. First, I estimate two random effect (RE) regressions of the WLS respondents' educational attainment which also control for unobserved family characteristics. In the first model, I include all explanatory variables except cognitive ability and in the second model I also include cognitive ability. These two models are used as a baseline for the RE-IV and to evaluate the validity of birth spacing as an instrument for cognitive ability. Second, I estimate the RE-IV model that jointly estimates both the indirect and the direct effect of sibship size on educational attainment.

⁴A closer inspection of the studies reviewed by Steelman et al. (2002) shows that some of these studies do not analyze birth spacing and educational success, and some studies do not find any link at all between birth spacing and educational success. First, Dandes and Dow (1969) use as the explanatory variable a measure that combines sibship size and spacing (the FSD index, see Waldrop & Bell, 1964) which means that they cannot distinguish the effect of birth spacing from the effect of sibship size. Second, Kidwell (1981) does not analyze educational outcomes at all but rather the effect of birth spacing on teenagers' attitudes towards parents' support and rearing practices. Third, Galbraith (1982) analyzes between- and within-family relationships between sibship density and intelligence and finds very small or no effects of sibship density. Fourth, when also controlling for cognitive ability Powell and Steelman (1993) find no effect of birth spacing on the probability of dropping out of high school. They do, however, find a small significant effect of birth spacing on the probability of attending any type of post-secondary education. However, their analysis is limited by the fact that they analyze if respondents *attend* rather than *complete* post-secondary schooling. Consequently, they do not analyze if birth spacing has an effect on whether their respondents actually complete post-secondary education.

In RE1 I regress respondents' educational attainment on all sibship characteristics and the socioeconomic and demographic controls. The model also controls for unobserved family characteristics. In this model, I find that sibship size has a highly significant negative effect of $-.092$, thereby indicating that on average each additional sibling "costs" a little less than one-tenth of a year of schooling.

This finding is consistent with both the CM and RDH suggesting that, as a consequence of either a poor intellectual climate in families with many children or due to resource dilution in large families, sibship size should have a negative effect on educational attainment. However, RE1 illustrates the fundamental inferential problem in much of the literature because this model cannot be used to determine if the negative effect of sibship size is due to the CM or the RDH.

In RE1 I also find a negative effect of being a first-born on educational attainment and a positive effect of birth spacing to the next older sibling. Interestingly, as predicted by the CM the longer is the spacing to the next older sibling the more education children obtain. By contrast, the negative effect for longer spacing to the next younger sibling is not significant. The effects of the socioeconomic and demographic variables are similar to those reported in previous studies. Parental income, education, and socioeconomic status have positive effects on educational attainment. Furthermore, farm origin has a positive effect while female respondents obtain less education than male respondents. Finally, I find that the estimate of the variance of the random effect σ_f^2 which summarizes the influence of unobserved family characteristics on educational attainment is highly significant and, furthermore, that the average within-family correlation in educational attainment is $.237$. Consequently, unobserved family influences play a considerable role and siblings from the same family tend to resemble each other with respect to their educational attainment.

In RE2 I include respondents' cognitive ability in the model. In this model, the effect of sibship size decreases from $-.092$ to $-.064$, thereby indicating that at least some of the effect of sibship size in RE1 is due to differences in respondents' cognitive ability. Several other important findings emerge. First, birth order is not significant in RE2. Second, none of the birth spacing variables are significant. Consequently, the effect of birth spacing to the next older sibling on educational attainment (which was significant in RE1) is fully explained by including cognitive ability in the model. This finding corroborates my assumption that birth spacing has no effect on educational attainment other than that going through cognitive ability and that birth spacing is a valid instrument for cognitive ability. Second, the effects of the socioeconomic background variables are attenuated in RE2 compared to RE1. This result illustrates that some of the effects of the socioeconomic background variables on educational attainment is mediated by cognitive ability.

Nevertheless, RE2 still does not adequately disclose if the CM or the RDH explains the negative effect of sibship size on educational attainment. The significant negative effect of sibship size net of cognitive ability (and unobserved family characteristics) supports Hypothesis B stating that sibship size should have an additional effect on educational outcomes that captures resource dilution mechanisms that are unrelated to children's cognitive ability. However, there are two reasons why RE2 remains inadequate.

First, RE2 does not explicitly model the indirect effect of sibship size on educational attainment running through cognitive ability. The magnitude of this effect is of theoretical and substantive interest in both the CM and RDH and should be modeled explicitly. Second, it is not correct to infer the magnitude of this indirect effect by comparing changes in the coefficient of sibship size in RE1 which omits cognitive ability ($\beta_1 = -.092$) and RE2 which includes cognitive ability ($\beta_1 = -.064$). The reason why is that changes in the coefficient of

sibship size may be caused both by the indirect effect of sibship on cognitive ability and by other unobserved variables that are correlated with sibship size and cognitive ability. In practice, this means that the reduction in the coefficient of sibship size from RE1 to RE2 cannot be uniquely attributed to the indirect effect of sibship size on cognitive ability. Although the random effect model controls for unobserved family characteristics it does not remedy this problem because, by design, it only controls for unobserved family characteristics that are *uncorrelated* with sibship size (see footnote 3).

The RE-IV model explicitly accounts for the direct effect of sibship size on educational attainment *and* its indirect effect running through cognitive ability. To recall, the RE-IV consists of two simultaneous models: a “second stage” model in which educational attainment is the dependent variable and a “first stage” model in which cognitive ability is the dependent variable. Furthermore, because sibship size appears as an explanatory variable in both equations its direct and indirect effect on educational attainment can be analyzed within a single methodological framework. The results from the RE-IV are also shown in Table 3.

From the RE-IV I find that sibship size has a significant negative effect both on cognitive ability and educational attainment. In the first stage regression the effect of sibship size on cognitive ability is estimated at $-.205$ ($p < .01$), while in the second stage regression of educational attainment the effect is $-.063$ ($p < .001$). My analysis then supports Hypothesis A stating that sibship size should have a negative effect on cognitive ability. Furthermore, my analysis also supports Hypothesis B stating that there should be a direct, negative “RDH effect” of sibship size on educational attainment. The latter conclusion is in contrast to the prediction from the CM that no such effect should exist.

The cognitive ability and educational attainment variables use different scales. This means that it is not possible to directly compare the relative magnitude of the sibship size effect on either outcome. However, expressed as fractions of a standard deviation in either outcome the negative effect on cognitive ability of adding one more child to the family is equivalent to about 1.4 percent of a standard deviation in the distribution of cognitive ability, holding all other factors constant. In comparison, the effect of increasing family size by one child on educational attainment is equivalent to about 2.6 percent of a standard deviation in the distribution of educational attainment, holding all other factors constant. Although a rough approximation, this comparison of the relative impact of the effects of sibship size suggests that the direct RDH effect on educational attainment is far stronger than the indirect effect on cognitive ability. Consequently, sibship size has a negative impact both on children’s cognitive ability and on their educational attainment, but the latter “RDH effect” on educational attainment is the stronger channel through which sibship size influences children’s outcomes.

Table 3 also shows the effects of the birth spacing instrumental variables on cognitive ability. First, I find that birth spacing to the next older sibling has a highly significant positive effect on cognitive ability. As predicted by the CM, the longer is the spacing between the respondent and his/her next older sibling the better cognitive ability the respondent has. On average, increasing birth spacing to the next older sibling by 1 year improves cognitive ability by around 4.7 percent of a standard deviation in the distribution of cognitive ability. The Z-value for the effect of birth spacing to the next older sibling (shown in brackets in Table 3) is 7.41 indicating that birth spacing to the next older sibling is very highly correlated with respondents’ cognitive ability (e.g., Staiger & Stock, 1997). Second, as expected from the CM the effect of birth spacing to the next younger sibling is negative. However, this effect is not significant. Third, family income, parents’ education, and father’s SES are highly significant predictors of both cognitive ability and educational

attainment. Finally, respondents with farm origin have higher cognitive ability than respondents with urban origin.

6. Discussion

The ambition of this paper was to jointly test the two major explanations of why sibship size has a negative effect on children's educational attainment: the Confluence Model (CM) and the Resource Dilution Hypothesis (RDH). There is an ongoing debate in the literature on whether the CM or the RDH offers the correct explanation of the observed negative correlation between sibship size and cognitive ability and educational attainment.

Unfortunately, most studies cannot distinguish empirically between the CM and the RDH. The reason why is that analysts generally only observe the end result of the CM and the RDH (a negative relationship between sibship size and educational attainment) and not the psychological or sociological processes that lead to this end result. However, the CM and the RDH differ with respect to how they theorize these processes. According to the CM sibship size affects children's outcomes through cognitive ability because families with many children provide a poorer intellectual climate than families with few children. By contrast, the RDH argues that large sibships generate strains on many types of parental resources which in turn lead to poorer child outcomes.

In this paper, I highlight an important theoretical difference between the CM and the RDH that can be used to distinguish the two theories: the role of cognitive ability. The CM states that the effect of sibship size on children's educational attainment runs exclusively through cognitive ability. By contrast, the RDH argues that cognitive ability is one among several channels through which sibship size negatively affects educational attainment. The implications of this theoretical difference can be tested empirically by investigating if sibship size affects educational attainment exclusively through cognitive ability or if an additional and direct "RDH effect" exists.

I analyze educational attainment in a sample of siblings from the Wisconsin Longitudinal Study (WLS). I propose a random effect Instrumental Variable model which separates the effects of sibship size on respectively cognitive ability and educational attainment and which furthermore controls for unobserved family heterogeneity. My findings are, first, that sibship size (also controlling for birth order and birth spacing) has significant and independent negative effects on both cognitive ability and educational attainment, and second, that the direct effect on educational attainment is stronger than the indirect effect on cognitive ability. My findings then substantiate the claim in the RDH that the effect of sibship size on educational attainment extends beyond its influence on children's cognitive capability. Furthermore, my results do not support the claim in the CM that cognitive ability is the only channel through which sibship size affects educational attainment.

While in this paper I have attempted to delineate the differences between the CM and the RDH, several empirical and analytical limitations in the research design should be highlighted. First, in many respects existing research (including the present paper) only scratches the surface with respect to understanding how sibship size affects children's cognitive and educational outcomes. Thus, although I find a significant negative effect of having many siblings on children's cognitive and educational outcomes, I do not claim to explain how this negative effect comes about. Consequently, while this paper takes a more comprehensive approach than previous studies to decomposing the different channels through which sibship size affects children's outcomes, the effects identified in this paper nonetheless represent fairly crude approximations to the complex family processes that shape educational outcomes.

Second, detailed comparisons of the CM and RDH are hampered by lack of appropriate data. In theory, a detailed test of the CM requires IQ measures for both parents and children over a considerable period of time to capture growth in children's cognitive ability (Zajonc & Mullally, 1997). Similarly, a detailed test of the RDH requires information on a wide array of parental resources (material, cultural, interpersonal, etc.) over time and measures of how parents allocate resources (e.g., Downey, 1995). At present, data that accommodates both perspectives does not exist, and researchers who want to compare the CM and RDH are limited to a general approach like the one used in this paper.

Finally, the limitations in the WLS mean that the results from the present analysis only generalize to whites who graduated from high school and who have at least one sibling. The relationship between sibship size and cognitive and educational attainment may work substantively different in other ethnic or socioeconomic groups (e.g., Krein & Beller, 1988; Shavit & Pierce, 1991). Future research should explore this possibility.

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Biography

Mads Meier Jæger, Ph.D., is a senior researcher at the Danish National Centre for Social Research. His research interests include social mobility, cultural consumption, and applied microeconometrics. He has published or has papers in press in, for example, *Social Forces*, *Social Science Research*, and *Rationality and Society*.

Fig. 1.
Illustration of effects in the random effect Instrumental Variable model.

Table 1

The role of different sibship characteristics on children's outcomes in the Confluence Model and the Resource Dilution Hypothesis.

	Sibship size	Birth spacing	Birth order
Confluence Model	Negative effect due to low family intellectual level	Positive effect for spacing to next <i>older</i> sibling due to higher family IQ; negative effect of spacing to next <i>younger</i> sibling due to lower family IQ	Positive effect for firstborns (+ "teaching effect"); Negative effect for lastborns
Resource Dilution Hypothesis	Negative effect due to resource dilution	None	None

Table 2

Descriptive statistics for the WLS sibling sample.

Variable	Mean	S.D.	N
Years of schooling	13.64	2.41	10,384
Cognitive ability	102.29	15.19	9,471
Sibship size	3.41	2.47	10,384
Firstborn	.31	.46	10,384
Lastborn	.24	.43	10,384
Birth spacing to next older sibling	3.76	2.79	10,324
Birth spacing to next younger sibling	4.06	3.00	10,300
Log family income	3.94	.67	9,956
Father's years of schooling	9.82	3.41	10,384
Mother's years of schooling	10.50	2.80	10,384
Father's SES	33.01	21.46	10,295
"Broken" family	.08	.28	10,384
Farm origin	.20	.40	10,384
Respondent's sex (=female)	.52	.50	10,384

Table 3

Random effect and RE-IV regressions of years of schooling. Parameter estimates with standard errors in parenthesis and Z-values in brackets.

Model	Random effect models		Random effect Instrumental Variable model	
	RE1	RE2	First stage (dependent variable: cognitive ability)	Second stage (dependent variable: years of schooling)
Sibship size	-.092 (.011) ***	-.064 (.010) ***	-.205 (.075) **	-.063 (.011) ***
Cognitive ability	–	.054 (.001) ***	–	.056 (.015) ***
Firstborn	-.121 (.045) **	-.037 (.044)	-.174 (.342)	.037 (.047)
Lastborn	.018 (.049)	.036 (.048)	-.170 (.318)	-.031 (.044)
Birth spacing to next older sibling ^a	.046 (.011) ***	.007 (.010)	.557 (.075) *** [7.41]	–
Birth spacing to next younger sibling ^a	-.018 (.010)	-.009 (.010)	-.043 (.070)	–
Log family income	.308 (.043) ***	.229 (.040) ***	1.210 (.289) ***	.227 (.043) ***
Father's years of schooling	.107 (.009) ***	.077 (.009) ***	.480 (.062) ***	.076 (.011) ***
Mother's years of schooling	.103 (.010) ***	.061 (.010) ***	.588 (.068) ***	.060 (.013) ***
Father's SES	.017 (.002) ***	.012 (.001) ***	.090 (.010) ***	.012 (.002) ***
"Broken" family	-.033 (.097)	.089 (.091)	-.745 (.656)	.091 (.091)
Farm origin	.184 (.069) *	.106 (.063)	1.739 (.456) ***	.103 (.068)
Respondent's sex (=female)	-.595 (.043) ***	-.644 (.041) ***	.007 (.296)	-.643 (.041) ***
Constant	10.256 (.202) ***	6.008 (.223) ***	83.374 (1.352) ***	5.785 (1.336) ***
R^2	.187	.292	.292	
$\tilde{\sigma}_f^2$	1.058 ***	.884 ***	.894 ***	
Within-family correlation in educational attainment ρ	.237	.202	.190	
N	9805	8964		8964

^aInstrument in RE-IV model.

**
 $p < .01$.

 $p < .001$ (two-sided).