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03:2007 WORKING PAPER

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How Sibship Size Affects Educational Attainment

RESEARCH DEPARTMENT OF SOCIAL POLICY AND WELFARE

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Social Policy and Welfare
Working Paper 03:2007

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Confluence Model or Resource Dilution Hypothesis? How Sibship Size Affects Educational Attainment

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Title:

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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 sibship size effect 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 having a negative effect on cognitive ability, sibship size also has a strong negative effect on educational attainment which is uniquely explained by the RDH.

Key words: Family background, educational attainment, sibship size, Confluence Model, Resource Dilution Hypothesis.

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 and Angst, 1983; Heer, 1985; Steelman, 1985; Steelman et al., 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 and Markus, 1975; Zajonc, 1976, 1983). In contrast, the RDH, originating in sociology and demographics, 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., Ernst and Angst, 1983; Steelman, 1985; Retherford and Sewell, 1991; Downey, 2001; 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., Featherman and Hauser, 1978; Blake, 1989; Conley, 2000; Steelman et al., 2002; Plug and Vijverberg, 2003; Sandefur et al., 2006). 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 and Steelman, 1990, 1993), parents' economic investments in children (e.g., Powell and Steelman, 1989, 1995), and parents' interpersonal resources and communication with children (e.g., Powell and Steelman, 1993; Downey, 1995; Cheung and Andersen, 2003). However, these studies are unable to determine if the CM or the RDH explains the observed negative relationship between sibship size and children's outcomes.

But is it possible to distinguish empirically between the CM and the RDH when analyzing the effect of sibship size on educational attainment? In this paper I 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 end up with 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 impact effect on educational attainment. This difference between the two theories has important empirical implications because, according to the CM, the negative effect on 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 is 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 et al., 1977) and that certain physiological or health problems are more prevalent in large than in small families (e.g., Belmont and 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 environmentally caused effects hypothesized by the CM and the RDH. To overcome this potential problem in the empirical analysis I analyze data on sibling pairs which allows me to control for unobserved family influences (e.g., Lindert, 1977; Olneck and Bills, 1979; Sandefur and Wells, 1999; Sieben et al., 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, while in section 4 I develop the empirical framework. Section 5 presents the results of the empirical analysis, and in section 6 I contemplate some avenues for future research.

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 in the empirical analysis to distinguish the implications of each theory.

The Confluence Model

The Confluence Model (CM) was formulated by Zajonc and colleagues (Zajonc and Markus, 1975; Zajonc, 1976, 1983). 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. The total intellectual level in the family is calculated as the average of the absolute intellectual level of all family members. Parents have much higher intellectual skills than children, but the arrival of a new child with low initial intellectual skills decreases the total intellectual level in the family. 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 and Markus, 1975: 77).

According to the CM, several other sibship characteristics are also important in determining children's intellectual ability. First, birth order effects are significant in that firstborns are particularly advantaged by not having other siblings who depress 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 determining children's intellectual ability. The reason why is that closely spaced siblings depress 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 and Markus, 1975; Zajonc, 1983).

The Resource Dilution Hypothesis

The Resource Dilution Hypothesis (RDH) is a general hypothesis of 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 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 as quickly (Downey, 1995; Steelman et al., 2002). Finally, unlike the CM, the RDH mechanism pertains to a broad spectrum of parental resources, and thus not only family characteristics or parental resources that affect children's cognitive ability.

Theoretical Differences between the CM and the RDH

To provide an answer to the problem of how to distinguish between the CM and the RDH it is important to examine where the two theories differ and how differences between the theories can be used to derive testable implications of each theory. 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 four fundamental sibship and sibling characteristics sibship size, birth spacing, birth order, and sibship sex composition.

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: 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. However, 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 crucial theoretical difference between the CM and the RDH provides a source of identification because it allows for a direct test of the two channels through which sibship size affect 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 and sibling characteristics (sibship size, birth spacing, birth order, and sibship sex composition). It is important to analyze these differences, first, to demonstrate where the two theories truly differ (the RDH is often formulated in such general terms that is seems a 'catch-all' theory) and, second, to determine how the two theories can be distinguished empirically. The theoretical role of sibship size, birth spacing, birth order, and sibship sex composition in respectively the CM and the RDH is summarized in Table 1.

TABLE 1 HERE

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.

Second, birth spacing comprises a key theoretical dimension in the CM but does not have any role in the RDH. Some proponents of the RDH argue that birth spacing affects educational outcomes because closely spaced births exert particular strains on parental resources (e.g., Powell and Steelman, 1990). However, within the logic of the RDH 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 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, this argument also assumes that closely spaced children are more resource demanding than children spaced further apart.[1] Consequently birth spacing does not play a role in the RDH. 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 an explicit theoretical role in the RDH. Some advocates of the RDH argue that birth order might matter in the RDH 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 and Tzeng, 1989; Powell and Steelman, 1990, 1993, 1995). However, these hypothesized effects are mostly borne out of empirical observations and are sometimes internally contradictory. Not surprisingly, Steelman et al. (2002: 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’.

Fourth, sibship sex composition is not part of the CM because male and female children are hypothesized to have the same mental ability and development. However, sibship sex composition may be of significance in the RDH in societal contexts (and, especially in Asia and Africa) where parents have preferences for certain sexes and these preferences determine parental resource allocations (Lee, forthcoming).[2]

Hypotheses

Based on my review of the CM and the RDH two hypotheses of the effect of sibship size on cognitive ability and educational attainment can be formulated

A. According to both the CM and RDH sibship size should have a negative effect on children's cognitive ability.
B. The RDH predicts that sibship size should have an *additional* direct, 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.

Data and Variables

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 Sewell and Hauser, 1980; Hauser and Sewell, 1985; Warren et al., 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 social 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 on all relevant sibship and sibling characteristics: sibship size, birth order, birth spacing, and sibship sex composition. These features make the WLS attractive for my research.

In this paper I analyze a sub sample of WLS respondents for whom information on final educational attainment is available for both the primary respondent and their randomly selected sibling. This restriction yields a gross sample of 5,192 respondent-sibling pairs which, when stacked into a single data set, has a total of 10,384 observations (i.e., 5,192 respondent and 5,192 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 in the empirical analysis I do not need to distinguish between the primary WLS respondents and their siblings (the two-level structure in the data is used to identify unobserved family effects, see below). The variables in the analysis are presented below.

While the WLS data is suited for my research it also has several limitations. First, being comprised of only high school graduates, 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 their 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).

Variables

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

TABLE 2 HERE

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: 440-41 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 total number of brothers and sisters the respondent has (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 the number of years between the respondent and the birth of the next older or younger sibling. Finally, *sibship sex composition* is measured by the relative share of boys in the sibship (with a range from 0 to 1).

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, as 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).

Statistical Model

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 should exist. 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 hereof, their educational attainment. According to the RDH, the indirect effect captures how large sibships drain parents' resources which lead to low cognitive performance among 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 ambition 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, conditional on the indirect effect, is statistically significant and thus contributes independently to explaining educational attainment.

The statistical framework used which simultaneously estimates 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 Figure 1.

FIGURE 1 HERE

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 marked with solid line arrows in Figure 1 and effects from the first stage regression are marked 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,…,N*) from family *j* (*j = 1,…,J*). In this model *s* represents 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 $\gamma^{'}$.

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

The ‘first stage’ regression in which cognitive ability is the dependent variable is

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

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 social background, sibship, and demographic variables with coefficient vector $\gamma_2^{'}$, and ε_{2ij} is a normally distributed error term with constant variance.

To simultaneously identify both Equation (1) and (2) I need an ‘instrumental’ variable *z* which appears only in Equation (2). I use *birth spacing* as instrument for cognitive ability in Equation (2) and assume that (controlling for sibship size and the *x* variables) birth spacing has no direct effect on educational attainment. Empirical evidence which supports the assumption of no direct effect of birth spacing on educational attainment net of cognitive ability is presented below.

Birth Spacing as an Instrument for Cognitive Ability

The usefulness of birth spacing as an instrument for cognitive ability depends on whether it is reasonable to assume, net of cognitive ability, that there is no direct effect of birth spacing on educational attainment (in Figure 1 there is no arrow from birth spacing to educational attainment). There are some theoretical arguments to support this hypothesis. In the CM births spacing is important for educational attainment only through its impact on cognitive ability. Longer spacing between successive siblings leads to a higher intellectual level in the family which in turn implies that children gain better cognitive ability. In the words of Powell and Steelman (1993: 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’. In contrast, birth spacing has no theoretical role in the RDH. Consequently, there are theoretical reasons to believe that birth spacing only affects educational attainment though cognitive ability.

Furthermore, there is little empirical evidence that birth spacing has a direct effect on educational attainment net of cognitive ability. In an influential review paper Steelman et al. (2002: 244-45) claim: ‘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 correct. Steelman et al. base their conclusion by citing Dandes and Dow (1969), Gailbraith (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 actual educational attainment. Consequently, the studies cited by Steelman et al. (2002) do not support the notion of a direct link between birth spacing and educational attainment.[3]

Results

This section presents the results of the empirical analysis. I estimate three models. First, I run 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 while in the second model I include cognitive ability. Second, I estimate the RE-IV model that jointly estimates both the indirect and direct effect of sibship size on educational attainment.

TABLE 3 HERE

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 shared by siblings that also affect educational attainment. In this model I find that sibship size has a highly significant negative effect of -.088, 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, as a consequence of either a poor intellectual climate in families with many children or due to resource dilution in large families, that sibship size should have a negative effect on educational attainment. However, RE1 illustrates the fundamental inferential problem in much of the literature because the 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 firstborn and a positive effect of birth spacing on educational attainment. The effects of the socioeconomic and demographic variables are similar to those reported in previous studies. Parental income, education, and socioeconomic has 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 $\tilde{\sigma}_f^2$ which captures unobserved family influences on educational attainment is significant, and, furthermore, that the average within-family correlation in educational attainment is .236. Consequently, unobserved family influences play a role and siblings from the same family tend resemble each other with respect to educational attainment.

In RE2 I include respondents’ cognitive ability. In this model the effect of sibship size decreases from -.088 to -.065, 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, both birth order and birth spacing is insignificant in RE2. Consequently, the effect of birth spacing on educational attainment (which was significant in RE1) is fully explained by cognitive ability. This finding supports my hypothesis and previous research arguing that there is no direct effect of birth spacing on educational attainment net of cognitive ability. Furthermore, the finding supports my use of birth spacing as an instrument for cognitive ability in the RE-IV. Second, the effects of the socioeconomic background variables are attenuated in RE2 compared to RE1. This result illustrates that some of the effect of socioeconomic background on educational attainment is mediated through 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. Second, it is not possible to deduce this indirect effect by comparing changes in the coefficients of sibship size in RE1 which omits cognitive ability ($\tilde{\beta}_1$ = -.088) and RE2 which includes cognitive ability ($\tilde{\beta}_1$ = -.065). The reason why is that changes in the coefficient of sibship size may be caused by both the indirect effect of sibship on cognitive ability but also the effect of other unobserved variables that are correlated with sibship size. By construction the random effect model does not remedy this problem because it only controls for unobserved family characteristics that are uncorrelated with sibship size.

The RE-IV explicitly models the direct effect of sibship 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 in a single framework. The results of the RE-IV are also shown in Table 3.

From the RE-IV I find that sibship size has a significant negative effect on both cognitive ability and educational attainment. In the first stage regression the effect of sibship size on cognitive ability is estimated at -.153 ($p < .05$), while in the second stage regression of educational attainment the effect is -.066 ($p < .001$). 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 meaning that a direct comparison of the relative impact of sibship size on either outcome is not possible. However, expressed as fractions of a standard deviation the negative effect on cognitive ability of adding one more child to the family is equivalent to about 1 percent of a standard deviation in the distribution of cognitive ability. In comparison, the effect of increasing family size by one child on educational attainment is equal to about 2.5 percent of a standard deviation in the distribution of educational attainment. Although a rough approximation, this comparison of the relative significance 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 on both children's cognitive ability and their educational attainment, but the latter effect on educational attainment is the stronger channel through which sibship size influences children's outcomes.

In the first stage regression I also find that the instrumental variable birth spacing has a highly significant positive effect on cognitive ability. As expected, the longer the spacing between the respondent and the next sibling the higher cognitive ability he or she has. The *Z*-value for the effect of birth spacing is 9.40 indicating that birth spacing is very strongly correlated with respondents' subsequent cognitive ability (e.g., Staiger and Stock, 1997). Furthermore, 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.

Conclusion and Discussion

The ambition of this paper was to 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 a major controversy in the literature on whether the CM or the RDH is 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 because analysts generally only observe the end result of the CM and the RDH (a negative relationship between sibship size and children's educational attainment) and not the psychological or sociological processes that generate this end result. However, the CM and the

RDH differ with respect to how they perceive 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. In contrast, the RDH argues that large sibships generate strains on many types of parents' 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 though cognitive ability. In 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 direct effect exists.

In the empirical analysis 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, birth spacing, and sibship sex composition) 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 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 though which sibship size affects educational attainment.

While in this paper I have attempted to delineate and test 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 impact of having many siblings on children's cognitive and educational outcomes, I do not claim to explain in detail how this negative impact is produced. Consequently, while this paper takes a more sophisticated approach than previous research to conceptualizing the different channels through which sibship size affects children's outcomes, the effects identified in this paper nonetheless represent fairly crude *marginal* effects. More research is needed to obtain a deeper understanding of these family processes.

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 and 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 neither perspective does not exist.

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

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	Sibship sex composition
Confluence Model	Negative effect due to low family intellectual level	Negative effect of close spacing due to low family intellectual level	Positive effect for firstborns (+ 'teaching effect'); Negative effect for lastborns	None
Resource Dilution Hypothesis	Negative effect due to resource dilution	None	None	Parental sex preferences may lead to differential resource allocation

Table 2 Descriptive Statistics for the WLS Sibling Sample

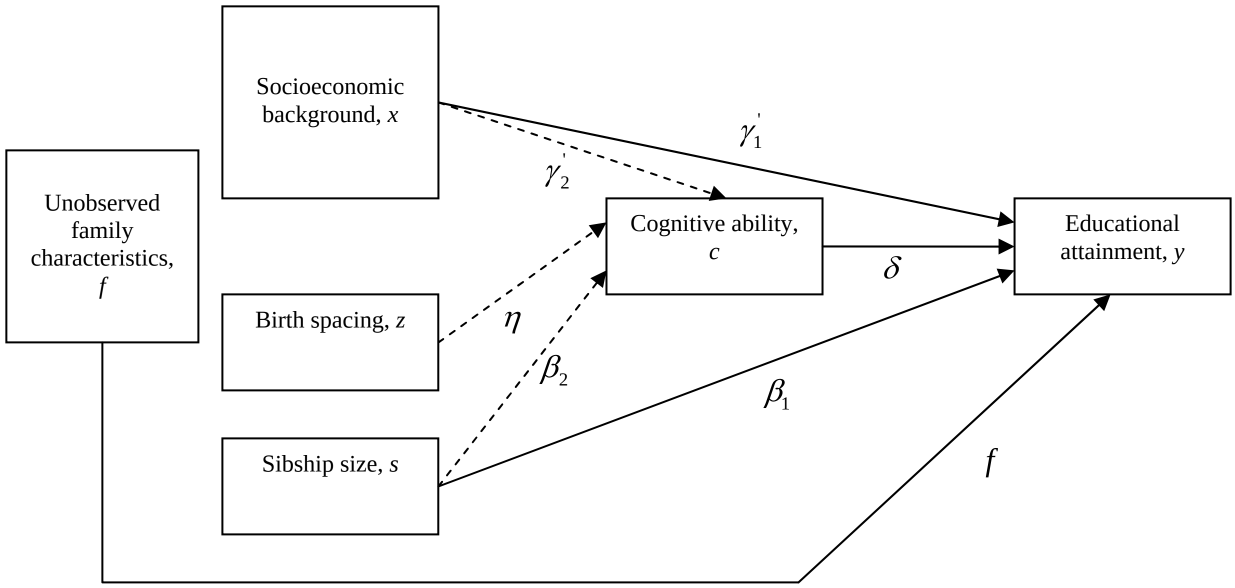
Variable	Mean	SD	*N*
Years of schooling	13.64	2.41	10,384
Cognitive ability	102.29	15.19	9,471
Sibship size	3.41	2.47	10,384
Firstborn	.31	.46	10,384
Lastborn	.24	.43	10,384
Birth spacing	3.44	2.71	10,281
Sex composition	.49	.27	10,384
Log family income	3.94	.67	9,956
Father's years of schooling	9.82	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	-.088 (.011)***	-.065 (.010)***	-.153 (.076)*	-.066 (.011)***
Cognitive ability	-	.054 (.001)***	-	.047 (.015)**
Firstborn	-.125 (.045)**	-.031 (.043)	-.391 (.312)	-.035 (.044)
Lastborn	.017 (.049)	.042 (.047)	-.312 (.340)	.038 (.047)
Sex composition	.183 (.104)	.158 (.097)	-.536 (.703)	.154 (.098)
Birth spacing[a]	.032 (.001)***	-.004 (.009)	.592 (0.63)*** [9.40]	-
Log family income	.309 (.043)***	.231 (.040)***	1.199 (.292)***	.239 (.044)***
Father's years of schooling	.107 (.009)***	.076 (.009)***	.474 (.063)***	.080 (.011)***
Mother's years of schooling	.103 (.010)***	.061 (.010)***	.592 (.069)***	.065 (.013)***
Father's SES	.017 (.002)***	.012 (.001)***	.091 (.010)***	.013 (.002)***
'Broken' family	-.036 (.096)	.087 (.091)	-.760 (.660)	-.082 (.092)
Farm origin	.182 (.069)**	.103 (.063)	1.722 (.460)***	.116 (.068)
Respondent's sex (= female)	-.551 (.049)***	-.605 (.047)***	-.081 (.337)	-.606 (.047)***
Constant	10.122 (.209)***	5.904 (.229)***	82.537 (1.415)***	6.485 (1.281)***
R^2	.187	.292	.290	
$\tilde{\sigma}_f^2$	1.055***	.883***	.935***	
Within-family correlation in educational attainment $\tilde{\rho}$	.236	.202	.219	
N	9,811	8,970	8,970	

Note: * $p < .05$, ** $p < .01$, *** $p < .001$ (two-sided), [a] instrument in RE-IV model.

Figure 1 Effects in the random effect Instrumental Variable model



Notes

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[1] Evidence for 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 used in this paper 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.

[2] Empirical evidence on the effect of sibship sex composition on children's outcomes, at least for the US, is inconclusive. Butcher and Case (1994) and Conley (2000) find significant effects of sibship sex composition on educational outcomes whereas Kaestner (1997) and Hauser and Kuo (1998) do not find any effect. Much of the literature on sibship sex composition is reviewed in Steelman et al. (2002).

[3] In fact, a 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 and 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 both 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 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 complete post-secondary education.

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