Birth Order, Family Size and Educational Attainment

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This paper investigates the effect of family size and birth order on educational attainment. An instrumental variables approach is used to identify the effect of family size. Instruments for the number of children are twins at last birth and the sex mix of the first two children. The effect of birth order is identified, by examining the relation with years of education for different family sizes separately. No significant effect of family size on educational attainment of the oldest child is found. Birth order has a significant negative effect. Potential mechanisms behind the birth order effects are investigated. The results show that birth order effects are not affected by the average age gap between children. Information on financial transfers shows that earlier born children have a higher probability of receiving money from their parents than later born children, also the amount they receive is higher. These results indicate that the allocation of parental resources is a potential mechanism behind the birth order effects.

Keywords: Human capital; educational economics

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1 Introduction

Many studies indicate that birth order and family size are important determinants of educational outcomes of children. Family size and birth order are strongly related, although family size differs between children from different families, while birth order differs between children within a family. In previous research often no clear distinction between sibship size and birth order is made and estimated effects of sibship size could be picking up the effect of birth order and visa versa. Because of the strong relation between birth order and family size this paper estimates the effects of both family background components on years of schooling, using the Wisconsin Longitudinal Study.

The relationship between family size and educational attainment can be the result of constraints on parental resources. When there are capital market imperfections and parents have many children, they can, for a given income, invest less in each child than if they have fewer children. This can cause a negative relationship between family size and educational attainment (Becker (1981)). Also numerous empirical studies have found a negative relationship between the number of siblings, and future economic and educational achievements.

This negative relationship between family size and educational achievements is however not necessarily proof of a negative effect of the number of children. The number of children is a choice variable of the parents and it might be that certain characteristics of parents, such as their educational attainments, affect both the number of children as well as the educational attainments of those children.

This paper uses an instrumental variable (IV) approach to identify the effect of sibship size on years of schooling of a first-born child. Two sources of exogenous variation in the number of children are used; twins at last birth, and the preference of parents for a mixed sibling sex composition. Like many studies, this paper finds a negative correlation between the number of children and child's years of schooling. This negative correlation declines however when control variables like parental schooling and birth order dummies are added. This signals that the observed negative correlation might not be causal. The IV results indeed are no longer significantly negative, but positive and insignificant. Although the standard errors are not small, these results indicate that exogenous variation in the number of children does not have a significant negative effect on the educational attainment of a first-born child.

Since including birth order dummies makes the coefficient on family size insignificant, it might be that the negative relation between family size and years of schooling was just picking up the impact of birth order. Models from psychology predict a decline in intellectual environment with birth order, which can cause a negative effect of birth order on educational achievements (Zajonc (1976)). Economists emphasize the constraints on available parental time and resources, which can cause children's schooling outcomes to decline with birth order (Becker (1981), Behrman (1997)).

This paper also identifies the effect of birth order, by estimating the effect on years of schooling separately for families with two, three, four or five children. Family size is correlated with birth order, and not taking this into account would give estimates of the birth order effects which might confound birth order with family size, or with family characteristics that are correlated with family size (Rodgers (2001)). Estimating the effect of birth order separately for families with a different number of children avoids this problem. For all family sizes examined in this paper, birth order turns out to have a significant negative effect on educational attainment. This decline in years of schooling with birth order turns out to be approximately linear.

Recent studies have also looked at the impact of family size (Cáceres-Delpiano (2006), Angrist et al. (2007)), birth order (Kantarevic and Mechoulan (2006)) or both (Black et al. (2005), Conley and Glauber (2006)). The findings in this paper are very similar to the findings of most of these papers in the sense that the results also show no significant causal impact of family size on years of schooling but a significant decline in educational attainment with birth order. The main contribution of this paper is that it goes beyond estimating the impact of birth order and family size, by investigating two potential mechanisms behind the estimated effects, competition between closely spaced siblings and the allocation of parental resources.

Different theories predict that birth order effects will be smaller when the time between births is larger. This paper investigates the effect of child-spacing, taking into account the possible endogeneity of the space between births, first by including family fixed effects and secondly by using the presence of twins as instrument.

To investigate whether restrictions on parental resources are behind the birth order effects, this paper exploits information about the amount of money parents report to have given to their children. This information about financial transfers to children makes it possible to investigate whether there is a causal impact of the number of children on the probability that a child receives money from his parents and whether this probability and the amount received vary with the birth order of the child.

The results show that the negative effect of birth order does not vary significantly with the average space between births. This results is robust to including family fixed effects and the use of the presence of twins as instrument. This paper further finds that earlier born children have a higher probability of receiving money from their parents and they receive a larger amount. These findings indicate that the allocation of parental resources is a potential mechanism behind the birth order patterns observed in children's schooling outcomes.

The plan of the paper is as follows. Section 2 will give an overview of the theoretical and empirical literature. Section 3 continues with a description of the data used. Section 4 gives the results on respectively the impact of family size and birth order. Section 5 investigates potential mechanisms behind the birth order effects and finally Section 6 concludes.

2 Theoretical and empirical background

Family size and educational attainment

There is an extensive theoretical literature about the trade-off between child quality and quantity, dating back to the models of Becker and Lewis (1973) and Becker and Tomes (1976). The idea behind these theoretical models is that if parents have more children, investing a certain amount in per-child quality, for example their education, is more expensive, than if they have fewer children. When there is an (exogenous) increase in the number of children, the total cost of investing a certain amount per child becomes higher and for a given budget constraint parents will lower the investment in per-child quality. This indicates that there is a negative relation between child quantity and child quality.

However, parents not only have an influence on child quality through investment of resources, but also through transmission of their endowments. If parents with lower endowments have a higher preference for child quantity than parents with higher endowments, and therefore also have more children, this can cause a negative correlation between child quantity and child quality, by way of the effect of parental endowments on child quality. Children of parents with low endowments will in this case have on average more siblings and a lower educational attainment, even though there may be no causal effect of the number of children on educational attainment.

The empirical studies investigating the relation between child quantity and quality usually perform a least squares regression of economic and educational outcomes on sibship size and other socioeconomic background variables. Most of these studies have found a significant negative relation between the number of children and the educational achievements of those children. Examples of these studies are Belmont and Marolla (1973), Blake (1981) and Hanushek (1992).

These studies do however not take the possible endogeneity of the number children into account. Recently the effect of family size on educational achievement is investigated using an instrumental variable approach. Black et al. (2005) use multiple births as instruments for the number of children, to investigate the effect of sibship size on children's education in Norway. They find a negative correlation between family size and educational attainment, but when they include control variables such as birth order dummies, and when they use the twin births as instruments, they find no significant negative effect of the number of children on educational attainment. They look only at Norwegian data and their results might not generalize to other countries. The study in this paper applies a similar methodology by using twins as instrument to identify the effect of family size using data from the United States. It further complements their paper by using the sex mix of the first two children as instrument for family size, next to the twins instrument.[1] By using both instruments the effect of family size can be identified using different sources of exogenous variation.

Conley and Glauber (2006) and Cáceres-Delpiano (2006) both use U.S. census data to estimate the effect of the number of children. Conley and Glauber use exogenous variation in sibling sex composition to estimate the causal effect of family size. They find no effect of family size for first-born boys but they do find effects for second born boys; an increase in the number of siblings reduces their likelihood of private school attendance and increases grade retention.

Cáceres-Delpiano uses multiple births as an instrument for family size. He finds significant effects on investment in child quality in the sense that a larger family reduces the likelihood that the oldest child attends private school, reduces the mother's labor force participation, and increases the likelihood that parents divorce. He does not find a significant impact on child outcomes, measured by grade retention.

These two studies do not investigate the effect of the number of siblings on the final schooling outcomes, and they only look at young children who still reside with their parents. Both studies restrict their samples to families where the total number of children living in the household is equal to the number of children the mother has ever given birth to. However, since the mothers are quite young this reported family size need not be equal to the desired or the eventually completed family size. In contrast the data set used in this paper contains completed family size and completed schooling outcomes for all children in a family, whether they are still residing with their parents or not.

Angrist et al. (2007) use exogenous variation in family size both due to twin births and due to the preference for a mixed sibling sex composition. They also include interactions of these

[1] Black et al. (2005) briefly mention some results using the sex mix of the first two children as instrument. They find a significant positive effect of the number of children on years of education, and they do not find the magnitude of their estimate credible.

instruments with ethnicity, exploiting the difference in the effects of the instruments for different ethnic groups. Using Israeli Census data they find negative and significant OLS coefficients, but using the instruments they find no significant effect of the number of children on educational and labor market outcomes.

The studies by Angrist et al., Black et al. and Caceres-Delpiano use twins at second or at a higher birth as instrument for the number of children. Families who had, for example, twins at second birth and who have more than three children in total would however likely have had more than three children anyway, even if they would not have had twins at second birth. The investigation in this paper uses instead twins at last birth and this prevents using multiple births as exogenous variation in the number of children, while the parents wanted more children anyway.

Birth order and educational attainment

Different theories predict a significant effect of birth order on future educational and economic achievements. An important model in the psychological literature is the confluence model, which is discussed by Zajonc (1976). The confluence model predicts the intellectual growth of a child to depend on its intellectual environment, whereby the intellectual environment is defined as a function of the average of the absolute intellectual levels of its family members. A first child enters an environment with two adult parents, so the average intellectual level is high. A second born enters a lower intellectual environment than the first-born, because his older sibling is part of the intellectual environment, and decreases the average intellectual level. A third child enters an even lower intellectual environment than the second born because of two older siblings etcetera. Since the intellectual environment declines with birth order, this model predicts a negative relation between birth order and educational attainment. Zajonc however stresses the effect of child-spacing, the larger the age gap between two siblings the smaller is the difference between the two children in their intellectual environment, and the smaller is the effect of birth order.

Economic theories underline the restrictions on available parental time and resources (Becker (1981), Behrman (1997)). Later born children probably spend on average less time with their parents than earlier born children. A first-born does not have to share his parent's time with siblings until a second child is born. The second child has to share parental time with its older sibling, but only from the moment a third child is born, he or she has to share with another sibling. So in particular if time spent in the early childhood is more important than time spent with children when they are older, later born children are disadvantaged compared to earlier born children, because parents cannot spend as much time with later born children, as they did with earlier born children.

Not only restrictions on the amount of available time can cause a negative effect of birth order, but also limitations on the amount of resources available to invest in the human capital of the children may cause a negative effect. If parents simultaneously decide on the number of children and the quality of those children, that is how much to invest in each of their children, no birth order effect would be expected, unless parents explicitly favor earlier born children over later born children. In the quantity-quality model it is implicitly assumed that parents take the cost of investment in their children into account when deciding on the number of children. However, if parents are not enough forward looking, or when it is difficult for parents to estimate the actual amount of resources necessary to invest in their children's education, later born children may find that most resources have been depleted by older siblings, at the moment they need resources to finance their education.[2]

Empirical studies have found different effects of birth order. Belmont and Marolla (1973) examine, next to the effect of family size, the effect of birth order for given family sizes. They find a steady decline in the average score on a military examination with birth order. Blake (1981) also examines the effect of birth order and does not find a systematic difference in educational attainment between first and last borns, and middle born children.

Hauser and Sewel (1985) use the sample of 9000 Wisconsin high school graduates of 1957 and their siblings. In this sample also no significant or systematic effects of birth order on educational attainment are found. A drawback of this sample is that all graduates have at least high school. Later in this paper the offspring of these graduates will be examined, and the variation in years of education is larger among the children in this sample, there are both children with more than a high school degree as children with less than a high school degree.

Hanushek (1992) studies the effect of family size and birth order on children's scholastic performance. He finds that earlier born children perform better, but that this is entirely because earlier born children have a higher probability of being in a small family. For fixed family sizes he finds no significant differences between first and last born children.

Behrman and Taubman (1986) study the birth order effect for the adult offspring of the twins in the National Academy of Science/National Research Council (NAS/NRC) sample. They find in contrast to the previous three studies, significant positive effects of being an early born on (age-

[2]A binding budget constraint can, however, also favor later born children over earlier born children. If parents have an upward sloping earnings profile and there are capital market imperfections, parents can even have more resources available to invest in later born children, than they had available for their earlier born children.

adjusted) schooling. Behrman and Taubman include the number of children next to other family background characteristics in their specification, because the estimates might confound birth order with family size. This does however not solve the problem entirely, it is still difficult to separate the effect of birth order and family size, and the number of children is likely endogenous. The study in this paper investigates the effect of birth order for families with two, three, four and five children separately. In this way estimated effects of birth order cannot confound with the effect of family size.

Black et al. (2005) use data from Norway. Next to the investigation of the effect of the number of children on years of schooling, they also examine the effect of birth order for different family sizes separately. By including birth order dummies they find a significant negative effect of birth order on educational attainment, for all family sizes examined.

Kantarevic and Mechoulan (2006) use the Panel Study of Income Dynamics and find that first-born children have a significantly higher educational attainment. They also estimate birth order effects by family size but due to small sample sizes the estimates become imprecise for larger families. This paper will also investigate the effect of birth order on educational attainment for children from the United States. The sample size used in this paper is larger than the sample used by Kantarevic and Mechoulan, which gives the possibility to estimate all specifications by family size and to get more precisely estimated coefficients. It further adds to the previous two papers by investigating some of the mechanisms which could be behind the estimated birth order effects.

3 Data

The data set used in the empirical study in this paper comes from the Wisconsin Longitudinal Study (WLS), which is a long-term study of a random sample of 10,317 men and women who graduated from Wisconsin high schools in 1957. Survey data were collected from the high school graduates in 1957, 1964, 1975, 1992, and 2004 and from a randomly selected sibling of the graduate in 1977, 1994, and 2005. The data contains, among others, information about social background, schooling, intergenerational transfers and relationships, and family characteristics. This paper will mainly use information from the last two rounds of the questionnaire since these contain updated information about completed years of schooling of all of the children of the graduates and of all the children of the selected siblings. This is important since the analysis will look at the effect of birth order and family size on the completed schooling outcomes of these children.

For the study in this paper the data set is reduced to include only married respondents, with a minimum of two and a maximum of five children. This selection of the data set is necessary to be certain that children lived together during their childhood. When parents get divorced it happens that some children live with their mother and the other children live with their father, and in these kinds of circumstances the number of children reported in the survey is not equal to the number of children that lived with the respondent during the childhood of the children.

Including only married respondents reduces the number of respondents to 6,980 graduates and 4,263 siblings.[3] Eliminating all respondents with less than two children and more than five children further reduces the data set to 5,762 graduates and 3,341 selected siblings. Families with more than five children are excluded, because in the birth order analysis families of different sizes are examined separately, and for families with more than five children this is not possible due to sample size problems. The sample is further restricted to families with only biological children, because it might be the case that adopted children are treated differently by their adoptive parents than biological children. Moreover, little is known about the age of adoption and since the effect of birth order is examined in this paper, adopted children who become part of a family some years after they were born might complicate the analysis.

In 2004/2005 4,877 of the graduates and 2,562 of the selected siblings responded to the follow up questionnaire. The final sample of children for whom we have completed schooling outcomes consists of 17,113 children from 5,990 families.[4] These children were born between 1943 and 1981, and 85% of these children was born between 1960 and 1975. On average they have completed 14.58 years of schooling. Table 1 gives some descriptive statistics of the sample.[5]

<Insert Table 1 about here>

[3]All regressions in this paper have also been performed without this selection of the data set and the results were very similar to those reported in the paper. To avoid complications in interpreting the results, for example when children did not live together during their childhood because their parents did not live together, only results for the selected sample are presented.

[4]There are some children below the age of 23 in 2004 and these children might still be in school. In the analysis we eliminate these observations. In the sample in this paper less than 2% is below the age of 23. It is unlikely that eliminating these observations can cause a significant bias in the estimates.

[5]Since the sample contains multiple children from one family, these observations are not independent. All the specifications are therefore estimated with clustered standard errors.

4 Results

Family size and educational attainment

In previous studies the relation between the number of children and the educational attainment of a child is usually estimated using an ordinary least squares specification. In this section the possible endogeneity of the number of children will also initially be ignored, and the following equation will be estimated three times, each time with a different set of control variables.

$$E_{child} = \alpha \cdot children + X \cdot \beta + \varepsilon \tag{1}$$

First X only contains dummies for the age and gender of the child, then the years of schooling of the father and the mother are included, and finally a set of dummies indicating whether the child is a second, third, fourth or fifth born are added to the specification. The highest level of education, measured in years of schooling, is used as dependent variable and the number of children ranges from two to five. Table 2 shows the estimation results of this equation.

<Insert Table 2 about here>

As can be seen in column 1 in Table 2, the coefficient on the number of children is significantly negative. The magnitude of the coefficient declines however when paternal and maternal education are added as control variables. This signals that the number of children is endogenous, and that the school choice of parents is somehow related to their decision about the number of children. Another possibility is that the negative effect of family size is picking up the negative effect of birth order. Therefore in column 3 birth order dummies are added, and indeed the coefficient on the number of children declines even further and is no longer significantly different from zero. The birth order dummies are however all significantly negative. It is not possible though to conclude from this table what the causal effect of the number of children is. It is also difficult to separate the effect of birth order and sibship size in column 3, because the number of children and the birth order dummies are strongly correlated.[6]

To identify the causal impact of the number of children on years of schooling of the first-born child, twins at last birth and the sex mix of the first two children will be used as instruments.[7]

[6] The correlation between a continuous variable birth order and the number of children is equal to 0.46. The continuous birth order variable has the value zero for a first-born child, the value one for a second-born child etc. The variable ranges from zero to four.

[7] See Rosenzweig and Wolpin (2000) for a discussion on the use of these instruments.

The variable twins at last birth takes on the value one in three situations; when there are three children in the family and the second birth is a twin, when there are four children and the third birth is a twin and the final situation is when there are five children and the fourth birth is a twin.

For twins at last birth to be a valid instrument for the number of children, it should have no separate effect on the educational attainment of the first-born child. If child-spacing has an effect on educational attainment, using twins at last birth as instrument could be a potential problem, because in the case of twins the space is zero. If the age gap between two children is smaller the competition between siblings for time and parental funds is likely higher, which can have a negative effect on the education of a child, separate from the effect via the number of children. Estimating, for fixed family sizes, the effects of the number of months between two subsequent births on years of schooling of the first-born child, gives coefficients which are all not significantly different from zero.[8] This indicates that the space between births has no significant effect on educational attainment. Later in this paper the effect of child-spacing will be investigated more thoroughly.

Another potential problem is that the probability of having twins at last birth might be affected by certain characteristics of parents, such as their educational attainment. Results from linear probability models show however that the education of both the father and the mother have no significant effect on the probability of having twins at last birth.[9] These results indicate that the instrument twins at last birth has no separate effect on years of schooling of the first-born child, although this remains of course an untestable assumption.

The second instrument takes on the value one when the first two children are two boys or two girls. If the first two children are of the same sex, parents are significantly more likely to have another child, because of the widely observed preference of parents for a mixed sibling sex composition (Ben-Porath and Welch (1976), Angrist and Evans (1998)).[10] For the sex mix of the first two children to be a valid instrument, it should also have no effect on the educational attainment of a child, separate from the effect via the number of children. Some papers indicate that the number of brothers and sisters can have an effect on educational outcomes. Butcher and

[8] Regressions are by family size and include the number of months between the second and third child (space23), between third and the fourth child (space34) and between fourth and fifth child (space45). All regressions include dummies for age and gender of the child and controls for father's and mother's years of schooling. Results for three child families: space23: 0.002(0.002), four child families: space23: -0.002 (0.003), space34: 0.001 (0.002), and for five child families: space23: -0.004 (0.007), space34: -0.005 (0.006), space45: -0.005 (0.004).

[9] The coefficient on father's education is equal to -0.0008 (0.0006) and the coefficient on mother's education is equal to 0.0007 (0.0007).

[10] Angrist and Evans also use the sex mix of the first two children as an instrument for the number of children, to test the effect of childbearing on labour supply.

Case (1994) find that, while controlling for family size, women raised with only brothers have a significantly higher educational attainment than women with any sisters. Hauser and Kuo (1998) report however that no effect of the sibling sex composition on educational attainment for the sample of 9000 Wisconsin high school graduates has been found. They go on to perform a similar analysis as Butcher and Case on three survey data sets, and they do not find any evidence for an effect of the gender composition of sibships on years of completed schooling. Also Kaestner (1997) does not find significant effects of sibling sex composition on the educational attainment of white males and females.

For the data set used in this paper, two dummy variables are added to the specification in equation (1), one for having only sisters and one for having only brothers, children with both brothers and sisters are the control group. Both dummy variables have an insignificant effect on the educational attainment of the first-born child.[11] These results indicate that the gender composition of sibships does not have a significant effect on educational attainment. So in the subsequent analysis it is assumed that the sex mix of the first two children has no effect on the schooling of the oldest child, separate from the effect via the number of children. The following model will be estimated

$$E_{child} = \alpha_0 + \alpha_1 \cdot children + X \cdot \beta + v \tag{2}$$

$$children = \delta_0 + \delta_1 \cdot Z + X \cdot \psi + \eta \tag{3}$$

Whereby Z is the instrumental variable for the number of children, and E_{child} is the completed years of schooling of the first-born child. Only the effect of the number of children on years of schooling of the oldest child is examined, because children who are born as second, third, fourth or fifth and who are part of a twin can be affected directly by the instrument twins at last birth. Children who are part of a twin have, for example, often a lower birth weight than children not part of a multiple birth and this might affect their later educational attainment (Black et al. (2007)).[12]

Table 3 shows the coefficients on the instruments twins at last birth and the sex mix of the first two children. Both instruments have a significant effect on the number of children. The partial F-statistic on the instrument twins at last birth is equal to 55.50, and equal to 21.16 for the instrument same sex. An instrument should have a sufficiently strong effect on the endogenous explanatory variable and an often used rule of thumb is that the partial F-statistic should be larger

[11] The coefficient on 'only sisters' is equal to -0.11 (0.08) and the coefficient on 'only brothers' is equal to 0.13 (0.08).

[12] Black et al. (2007) find using within twin techniques with data from Norway, that birth weight has a significant effect on educational attainment.

than 10, which is the case for both instruments here.[13]

<Insert Table 3 about here>

Table 3 also shows the OLS results for the first-born child, without taking into account the potential endogeneity of the number of children. The OLS coefficient in column 1 is negative but not significantly different from zero.[14] The second stage estimation results in columns 2 and 3 show that the effect of the number of children on years of schooling of the oldest child is positive, but not significant. Although the standard errors are not small, this indicates that there is no causal impact of the number of children on years of schooling, because both second stage results give a positive coefficient on the number of children, irrespective of whether twins at last birth or the sex mix of the first two children is used as instrument.[15] This result is similar to findings by recent studies using exogenous variation in the number of children to estimate the effect on years of schooling, in the sense that these studies also find no significant negative effect of family size (Black et al. (2005) and Angrist et al. (2007)).

Birth order and educational attainment

Table 2 showed that including birth order dummies makes the coefficient on the number of children smaller and insignificantly different from zero, while all the birth order dummies are significantly negative. It could be that the negative coefficients on family size in columns 1 and 2 were just picking up the effect of birth order. To identify the effect of birth order, equation (4) will be estimated separately for families with two, three, four and five children, such that estimated effects cannot confound with the effect of family size, or with family characteristics which are correlated with family size.

$$E_{child} = \beta \cdot birthorder + X \cdot \phi + \eta \tag{4}$$

Table 4 gives the results of estimating equation (4). For each family size the first column gives the estimates of including a set of dummy variables indicating whether the child is a second, third,

[13] Staiger and Stock (1997) investigate the finite sample bias of the IV estimator relative to the bias of the OLS estimator. They find that in a simple model the inverse of the F-statistic is an approximate estimate of the relative bias of the IV estimator. If the F-statistic is larger than 10, this gives a finite sample bias of the instrumental variable estimator of no more than 10 % of the OLS bias.

[14] The specification in column 1 in Table 3 is comparable to the specification in column 3 in Table 2. Column 3 in Table 2 controls for parental schooling and birth order and column 1 in Table 3 controls for parental schooling and is conditional on birth order since it only looks at first-born children.

[15] Due to the large standard errors it is however not possible to reject the hypothesis that the IV coefficients are equal to the OLS coefficient.

fourth or fifth born, and X includes dummies for age and gender of the child.[16] For all family sizes considered, the birth order dummies are all significantly negative, and the higher the birth order the more negative the effect is. The decline in years of schooling with birth order is approximately linear. Also the estimated birth order effects are very similar for the different family sizes. There is for example no large systematic difference between the effect of being a third born child in a three child family and being a third born in a four child family, whereas for a given family size there is a large difference between children with a different birth order.

<Insert Table 4 about here>

Because birth order has an effect which is almost linear, the effect of birth order could as well be estimated by using a continuous variable, which has the value zero when an individual is a first-born, the value one when he or she is a second born etc. This gives a variable which ranges from zero to four. Results using this continuous variable instead of the birth order dummies are shown in the second columns in Table 4. These results also show that birth order has a relatively large negative effect on years of schooling. The coefficient is between 0.29 and 0.40 for all family sizes considered.

Since the WLS contains information about completed years of schooling for all the children within a family, it is possible to estimate equation (4) including family fixed effects. By including family fixed effects, birth order effects are identified on the basis of within family variation and it removes all observed and unobserved family characteristics that are constant over time. The results in Table 4 show that although the coefficients become somewhat smaller, including family fixed effects does not change the conclusion that child's years of schooling significantly declines with birth order.[17]

One possible reason for the negative effects is that the intellectual environment declines with birth order, like Zajonc predicts in his confluence model. Another possibility is that earlier born children receive a larger share of parental time and resources compared to their later born siblings. The next section will investigate whether parental resources or competition between closely spaced siblings are behind the negative effect of birth order.

[16]Later born children are younger, it is therefore important to include controls for birth cohort (age of the child), since educational opportunities might change over time.

[17]Only for two child families the coefficient is no longer significantly different from zero, which can be due to the large increase in the standard error.

5 Potential mechanisms behind the birth order effects

The effect of child-spacing

Different theories predict that if families are more closely spaced, birth order effects will be larger. The confluence model from psychology states that the intellectual environment that later born children enter, will not differ much from the intellectual environment that earlier born children entered, when the age gap between earlier born and later born children is sufficiently large. When earlier born children are already almost adults when a child is born, this child does not suffer much from his higher birth order, in terms of a lower intellectual environment. This theory therefore predicts a decline in the birth order effects with the average space between births.

Also economic theories that stress the importance of resources predict that birth order effects will be smaller when the space between children is larger. If there are constraints on parental time this likely hurts later born children more than earlier born children, since later born children have to share the available time with their siblings for a larger part of their childhood. The constraints on the time that parents can spend with their children will however be less severe if the births of children are spread out over a longer time period. Birth order effects are therefore expected to be less negative when the average time between the births of the children is larger.

To test the effect of the average number of months between births, the following two equations will be estimated.

$$\mathrm{E}_{child} = \alpha_0 + \alpha_1 \cdot birthorder + \alpha_2 \cdot averagespace + X \cdot \beta + \varepsilon \qquad (5)$$

$$\begin{aligned} \mathrm{E}_{child} = \delta_0 + \delta_1 \cdot birthorder + \delta_2 \cdot averagespace \\ + \delta_3 \cdot (averagespace \times birthorder) + X \cdot \gamma + \eta \end{aligned} \qquad (6)$$

The first equation includes the average number of months between births in a family of two, three, four or five children. The continuous birth order variable is included in the regression as well as years of schooling of the father and mother, and dummies for the age and gender of the child. If competition between closely spaced siblings has a negative effect on their educational attainment, the coefficient on the average space will likely be positive. Also the confluence model predicts a positive coefficient.

The second equation includes as an extra variable the interaction of birth order and the average number of months between births, so as to investigate how spacing affects the effect of birth order.

If the negative effect of birth order is indeed smaller when the average time between births is larger, the coefficient on the interaction term (δ_3) will be positive. Table 5 shows the estimation results of the two equations.

<Insert Table 5 about here>

The average number of months between two births does not have a significant effect on the educational attainment of a child, as can be seen in Table 5. Also the interaction terms of birth order and the average space are insignificant and this holds for all family sizes. These results indicate that competition between closely spaced siblings does not seem to be an important cause of the negative effect of birth order.

The time between subsequent births can however be chosen by the parents. If certain characteristics of parents have an effect on the average space between births, as well as on the education of the children, the average number of months between births is endogenous. The last columns in Table 5 estimate equation (6) including family fixed effects, to control for parental characteristics that might be correlated with child-spacing and that are fixed over time. The results show that including family fixed effects does not change the results, the coefficients on the interaction between birth order and the average space are very small and none of them is significantly different from zero.

The fixed effect specification only controls for parental characteristics that do not change over time, and therefore does not fully solve the potential endogeneity of the spacing between births. To identify the causal effect of the average time between births, the presence of twins among the children in a family is used as an instrument. If a twin is born the space between two births is zero, which is an exogenous decrease in the average time between births. The following two equations will be estimated

$$\mathrm{E}_{child} = \alpha_0 + \alpha_1 \cdot averagespace + X \cdot \beta + v \tag{7}$$

$$\mathrm{E}_{firstborn} - \mathrm{E}_{lastborn} = \delta_0 + \delta_1 \cdot averagespace + X \cdot \phi + v \tag{8}$$

Whereby the average space is instrumented by a variable which takes on the value one when either the first, second, third or fourth birth is a twin.

A twin birth also has a significant effect on the number of children as was shown in the previous section. The equations above will however be estimated separately by family size, so this will not be an issue here. Another potential problem is that if the education of a child is affected by being part of a twin the instrument could have an effect on years of schooling separate from the effect via the average space.[18] For children from families with at least three children it is possible though to estimate equation (7) excluding the children who are part of a twin.

Table 6 shows the effect of the average number of months between births on child's years of schooling, as well as the coefficients from the first stage and the partial F-statistics. The presence of twins has a significant negative effect on the average number of months between births. There is no effect though of the average space on child's years of schooling, except for four child families, but this is only significant at the margin. These findings confirm the results in Table 5.

<Insert Table 6 about here>

To investigate whether child-spacing affects the difference in schooling between earlier and later born children, Table 7 shows the results of estimating equation (8). Sample sizes in Table 7 are smaller because it looks at the difference between the first and the last born child and therefore uses only one observation per family. The second stage results show that if the time between births is larger this does not change birth order effects, since the average space has no significant effect on the schooling difference between the first and the last born child.[19]

<Insert Table 7 about here>

The allocation of parental resources

Although economic theories, that stress the importance of parental resources, predict birth order effects to decline with the average space between births, the finding that spacing does not affect the birth order patterns does not rule out that the allocation of time and other parental resources is a potential mechanism behind the birth order effects. Price (2008) finds for example that parents spend equal amounts of time with their children at a particular point in time, but they spend less time with their children when the first-born child becomes older. This hurts later born children, because at a particular age later born children receive less quality time compared to the amount of quality time received by the first-born child at that same age. This could be an explanation for the negative effect of birth order on children's schooling outcomes.

The Wisconsin Longitudinal Study does not contain information about the amount of time parents spend with there children. It does however contain information about financial transfers

[18]As was already mentioned in previous sections, children part of a twin have on average a lower birth weight compared to singletons and this might affect there later educational attainment.

[19]Except for four child families, but again only significant at the margin.

to children. In 1992 respondents (both the graduates and the selected siblings) were asked whether they or their spouse had given or loaned any of their children $1000 or more between 1975 and 1992. The questionnaire contained seven different reasons for giving money; educational expenses, down payment on a home, enter or continue business or farm, increase wealth or decrease debt, medical expenses, housing or other living expenses, and other. For each reason the respondents were asked whether they or their spouse had given or loaned money for that reason to any of their children. If the respondent answered yes the next question was which child received the most money, second most, third most etc. For any child that received money the total amount received was determined. Parents could report that they gave equal amounts to their children. In that case the amount given to the child who received the most is equal to the amount given to the child who received the second most etc.

The WLS data set does not contain the direct answers to the questions described above. Instead it contains variables with the birth order of the child who received the most, second most, third most etc, variables with the amount received by the child who received the most, second most, etc and variables with the main reason for receiving money. These variables were created by matching the name of the child who received money to the same name in the children's roster. This children's roster contains characteristics of all of the children of the respondent, such as their birth order, gender and years of schooling.[20] Based on these variables it is possible to determine for each child whether it received any money from his parents between 1975 and 1992, and if so the amount he or she received.

Less than 2% of the respondents refused to answer questions about giving to children. About 23% answered that they did not give any money to their children and another 7% reported giving money to at least one child but responded with don't know or refused to all questions about the amounts given. Only adult children could have possibly received money from their parents because of the reasons for giving described above. The analysis below will therefore use a sample of families in which all children were older than 25 in 1992, such that all children within a family had the possibility of receiving money from their parents.

The analysis below will look at two variables. The first variable takes on the value one when a child received $1000 or more from his parents and takes on the value zero otherwise. The second variable contains the amount. This variable is defined for families in which at least one child received money and is equal to $1000 or more if the child received money from his parents.

[20] In 90% of the cases a computer program was able to match the name and another 7% were matched by hand-coding, the remaining 3% could not be matched because the name was not in the roster or because of a response such as "son" when there was more than one son etc.

Before investigating whether the financial transfers are affected by the number of children or the birth order of the children, Table 8 estimates the relation between receiving money from parents and child's years of schooling.

<Insert Table 8 about here>

The results show that children who receive \$1000 or more from their parents have a significantly higher educational attainment. To see whether the amount they receive is important, Table 8 also includes a specification with the natural logarithm of the amount received as explanatory variable.[21] For all family sizes considered the logarithm of the amount received is significantly related to child's years of schooling. Although the results do not necessarily reflect a causal impact of receiving money on educational outcomes, it does indicate that if receiving money differs by birth order, this could be a potential mechanism behind the birth order effects, especially since for about 60% of the children the main reason for receiving money was to cover their educational expenses.

The quantity-quality model predicts that the investment in child quality will be lower when there are more children. To investigate whether the number of children indeed negatively affects the probability that the first-born child receives money, Table 9 shows the effect of estimating equation (9), whereby the dependent variable takes on the value one when the first-born child received \$1000 or more from his parents, and X includes dummies for age and gender of the child.

$$Anymoney = \alpha + \beta \cdot children + X \cdot \phi + \varepsilon \tag{9}$$

<Insert Table 9 about here>

Column 1 of Table 9 shows that the probability that the first-born child receives any money is significantly negatively related to the number of children. To account for the endogeneity of family size, column 2 shows the results when the number of children is instrumented by both twins at last birth and the sex composition of the first two children. The IV estimate is lower than the OLS estimate and is no longer significantly different from zero, indicating that neither the investment in children nor their completed schooling outcomes are significantly affected by an increase in the number of children.[22]

[21] This variable is created by taking the logarithm of the amount plus 1, so as to account for the fact that some children received an amount of zero.

[22] Due to the large standard errors it is however not possible to reject the hypothesis that the IV coefficients are equal to the OLS coefficient.

To investigate whether receiving money varies with the birth order of the child, the following two equations will be estimated separately for different family sizes.

$$Anymoney = \alpha + \beta \cdot birthorder + X \cdot \phi + \varepsilon \tag{10}$$

$$lnamount = \gamma + \delta \cdot birthorder + X \cdot \pi + \eta \tag{11}$$

Table 10 shows the results of estimating equation (10). The results show that the probability of receiving money significantly declines with the birth order of the child. Only for five child families the coefficient is not significantly different from zero.

<Insert Table 10 about here>

Table 11 estimates the effect of birth order on the logarithm of the amount received for families in which at least one child receives money. To account for the fact the amount is a censored variable, since the amount is only specified for children that received $1000 or more, the censored least absolute deviations (CLAD) estimator introduced by Powell (1984) is used to estimate equation (11). The CLAD estimator, or conditional median regression, is a semi-parametric method to account for censored observations and can be used if less than 50% of the observations are censored, because then the censored sample median provides a consistent estimate of the population median. Since for five child families less than half of the observations received an amount of $1000 or more, only two, three and four child families are investigated.

<Insert Table 11 about here>

The results in Table 11 show that not only the probability to receive any money from parents is higher for earlier born children but also the amount received varies with the birth order of the child. Later born children receive significantly less money than earlier born children. These results indicate that restrictions on parental resources are a likely mechanism behind the negative birth order effects that are found in this and in other studies.

6 Conclusion

This paper has investigated the causal effect of the number of siblings and birth order on years of schooling. By using twins at last birth and the sex mix of the first two children as instruments, the effect of the number of children on the educational attainment of the oldest child is identified.

Although the OLS estimate of the effect of the number of children on child's years of schooling is negative, the IV results show a positive and insignificant effect of the number of children on years of schooling of the oldest child. This indicates that the negative correlation between sibship size and educational attainment found in this paper, and found in other papers (Belmont and Marolla (1973), Blake (1981), Hanushek (1992)), might actually be caused by unobserved family characteristics, which affect the number of children as well as the educational achievements of those children.

The effect of birth order is identified by investigating the effect of birth order for two, three, four and five child families separately. Birth order turns out to have a significant negative effect on years of education, for all family sizes examined. This is in contrast to the findings by Blake (1981), Hauser and Sewel (1985) and Hanushek (1992) but the results are very similar to those found by Behrman and Taubman (1986), Black et al. (2005) and Kantarevics and Mechoulan (2006).

Although a number of studies have investigated the impact of birth order and family size on educational outcomes, very few papers have studied potential mechanisms behind these effects. This paper has looked at two potential mechanisms, competition between closely spaced siblings and the allocation of parental resources to children. Child-spacing, measured by the average number of months between births, does not affect the birth order patterns that are observed in children's schooling outcomes. This results is robust to including family fixed effect and the use of the presence of twins as instrument.

The results on financial transfers to children show a negative birth order pattern just as the results found on children's schooling outcomes. The differential allocation of resources to earlier and later born children could therefore be a reason for the negative effect of birth order on child's years of schooling. But why would parents give less money to later born children? One possible explanation is consistent with the resource dilution idea. If parents are not enough forward looking or if they have difficulties in estimating the amount of money necessary to invest in their children's schooling, it could be that later born children will find that most parental resources have been used by earlier born siblings at the moment they need money to go to college.

Another explanation could be that earlier born children already receive a larger share of parental time and resources (such as a bigger room) when they are young. This could make earlier born children do better in school and if parents invest in the children that perform best in school, this might be a reason why earlier born children have a higher probability of receiving money from their parents.

Both explanations suggest that parental resources are a likely mechanism behind the birth order effects. However, more research is necessary to get a better understanding of why parents tend to allocate more resources to earlier born children. Also information about resource allocation and the effect on schooling outcomes when children are still quite young would provide more insight into the exact mechanisms behind the estimated birth order effects.

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Table 1: Descriptive statistics

	Mean	std. dev.
Child's years of schooling	14.58	2.31
Age child in 2004	38.12	5.48
Gender (girl=1)	0.49	0.50
Number of children	3.33	0.99
Father's years of schooling	13.57	2.66
Mother's years of schooling	12.94	1.78
Twins at last birth	0.01	0.11
Twin present	0.03	0.17
First two children of same sex	0.51	0.50
Average space (in months)	34.03	16.40
Child received money from parents[a]	0.46	0.50
Amount child received from parents[b]	7200.81	15113.82
Number of families	5990	
Number of observations	17113	

[a,b]Based on a sample of children from families in which all children were older than 25 in 1992. [a]N=5695 [b]N=4059

Table 2: The effect of the number of children on child's years of schooling

	(1)	(2)	(3)
Number of children	-0.24***	-0.11***	-0.03
	(0.02)	(0.02)	(0.02)
Fathers years of schooling		0.27***	0.26***
		(0.01)	(0.01)
Mother's years of schooling		0.23***	0.23***
		(0.01)	(0.01)
Second born			-0.26***
			(0.03)
Third born			-0.39***
			(0.05)
Fourth born			-0.50***
			(0.06)
Fifth born			-0.49***
			(0.11)
Number of families	5990	5990	5990
Number of observations	17113	17113	17113

All regressions include dummies for age and gender of the child.
Standard error (in parentheses) allow for correlation within families.
*significant at 10% level, **significant at 5% level, ***significant at 1% level.

Table 3: OLS & IV results: effect of number of children on years of schooling of the first-born child

	OLS		IV		IV	
			Twins at last birth		Same sex	
	(1)		(2)		(3)	
Number of children	-0.02	(0.03)	0.30	(0.37)	0.59	(0.52)
Coefficient first stage			0.89***	(0.12)	0.11***	(0.02)
Partial F-statistic first stage			55.50		21.16	
Number of observations	5735		5735		5735	

All regressions include dummies for age and gender of the first-born child, and controls for father's and mother's years of schooling. Standard errors are in parentheses.
* significant at 10% level, ** significant at 5% level, *** significant at 1% level

Table 4: The effect of birth order on child's years of schooling, by family size

	Two child family			Three child family			Four child family			Five child family		
Birth order		-0.31***	-0.16		-0.40***	-0.26***		-0.36***	-0.27***		-0.29***	-0.20**
		(0.06)	(0.15)		(0.04)	(0.07)		(0.04)	(0.06)		(0.05)	(0.08)
Second born	-0.31***			-0.44***			-0.45***			-0.49***		
	(0.06)			(0.06)			(0.08)			(0.13)		
Third born				-0.80***			-0.80***			-0.57***		
				(0.07)			(0.09)			(0.15)		
Fourth born							-1.10***			-1.10***		
							(0.11)			(0.16)		
Fifth born										-1.13***		
										(0.20)		
Family fixed effects	no	no	yes	no	no	yes	no	no	yes	no	no	yes
Nr. families		2099			2091			1262			538	
N		4020			5919			4699			2475	

All regressions include dummies for age and gender of the child. Standard errors (in parentheses) allow for correlation within families.
* significant at 10% level, ** significant at 5% level, *** significant at 1% level.

Table 5: Effect of the average space, birth order and the interaction of the two on child's years of schooling

	Two child family			Three child family			Four child family			Five child family		
(Average space ×birth order)		0.000	-0.013		-0.001	0.000		0.003	-0.003		-0.001	0.002
		(0.003)	(0.016)		(0.002)	(0.004)		(0.002)	(0.003)		(0.004)	(0.005)
Average space	-0.003	-0.003		0.001	-0.000		-0.002	-0.005		-0.011	-0.009	
	(0.002)	(0.002)		(0.002)	(0.003)		(0.004)	(0.005)		(0.007)	(0.010)	
Birth order	-0.15**	-0.15	-0.11	-0.24***	-0.29***	-0.24**	-0.21***	-0.29***	-0.27***	-0.17***	-0.13	-0.17
	(0.06)	(0.12)	(0.17)	(0.04)	(0.07)	(0.09)	(0.04)	(0.07)	(0.08)	(0.05)	(0.11)	(0.13)
Family fixed effects	no	no	yes	no	no	yes	no	no	yes	no	no	yes
Nr. families		2013			1936			1125			457	
N		3861			5502			4209			2121	

All regressions include dummies for age and gender of the child and controls for father's and mother's years of schooling. Standard errors (in parentheses) allow for correlation within families. * significant at 10% level, ** significant at 5% level, *** significant at 1% level.

Table 6: Effect of the average space on years of schooling, instrumented by the presence of twins

	Three child family		Four child family		Five child family	
Average space	-0.03	(0.02)	-0.05*	(0.02)	-0.03	(0.04)
Coefficient first stage	-12.32***	(2.57)	-9.34***	(1.06)	-6.54***	(0.95)
Partial F-statistic first stage	23.04		77.62		47.20	
Number of observations	5434		4103		2059	

[a]Excluding children who are part of a twin. Regression includes dummies for age and gender of the child, father's and mother's years of schooling and birth order. Standard errors (in parentheses) control for correlation within families. *significant at 10% level, **significant at 5% level, ***significant at 1% level

Table 7: Effect of average space on schooling difference first and last born. Instrumented by presence of twins

	Three child family		Four child family		Five child family	
Average space	0.01	(0.03)	0.09*	(0.05)	-0.12	(0.12)
Coefficient first stage	-11.85***	(2.70)	-8.04***	(1.61)	-5.28***	(1.83)
Partial F-statistic first stage	19.27		24.80		8.29	
Number of observations	1718		1020		402	

Regression includes control variables for gender of the first and last born child and father's and mother's years of schooling. Standard errors are in parentheses.
*significant at 10% level, **significant at 5% level, ***significant at 1% level

Table 8: Regressing child's years of schooling on probability of receiving money/amount received

	Two child family		Three child family		Four child family		Five child family	
Received any money	1.40*** (0.13)		1.44*** (0.11)		1.46*** (0.14)		1.29*** (0.22)	
Ln(amount)		0.18*** (0.02)		0.16*** (0.02)		0.14*** (0.02)		0.09*** (0.03)
N	1583	1203	2160	1582	1349	876	603	398

All regressions include dummies for age and gender of the child. Standard errors (in parentheses) allow for correlation within families.*significant at 10% level, **significant at 5% level, ***significant at 1% level

Table 9: Effect of the number of children on the probability that first-born child receives money

	OLS (1)		IV (2)	
Number of children	-0.07***	(0.01)	-0.03	(0.11)
Coefficients first stage:				
twins at last birth			0.97***	(0.19)
same sex			0.10***	(0.04)
Partial F-statistic first stage			14.65	
Number of observations	1973		1973	

All regressions include dummies for age and gender of the first-born child. Standard errors are in parentheses.* significant at 10% level, ** significant at 5% level, *** significant at 1% level

Table 10: Effect of birth order on probability of receiving any money from parents

	Two child family		Three child family		Four child family		Five child family	
Birth order	-0.08***	(0.02)	-0.04**	(0.02)	-0.04**	(0.02)	0.01	(0.02)
N	1583		2169		1349		603	

Regression includes dummies for age and gender of the child. Standard errors (in parentheses) control for correlation within families. *significant at 10% level, **significant at 5% level, ***significant at 1% level

Table 11: Effect of birth order on the logarithm of the amount received from parents (CLAD estimator)

	Two child family		Three child family		Four child family	
Birth order	-0.36***	(0.14)	-0.34**	(0.15)	-0.51*	(0.30)
Number of observations	1203		1582		876	

Regression includes controls for age and gender of the child. Standard errors (in parentheses) control for correlation within families.*significant at 10% level, **significant at 5% level, ***significant at 1% level