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ABSTRACT

HOW DOES SIZE OF SIBSHIP MATTER?
REVISITING FAMILY CONFIGURATION AND THE EFFECT OF FAMILY BACKGROUND ON EDUCATIONAL ATTAINMENT

Using data from the Wisconsin Longitudinal Study for full sibships of sizes two to five, we estimate models of the effects of social background, size of sibship, and gender on sibling resemblance in educational attainment. We find no differences in educational attainment by gender composition within those family sizes. Smaller sibships obtain more schooling, and men obtain more schooling than women. Smaller families are more heterogenous than larger families, but the effects of measured social background characteristics do not vary by size of sibship or gender composition of sibship. The effects of social background variables on the schooling of women are uniformly smaller than among men, and the non-shared (within-family) variations in schooling are much less among women than among men. These findings could lead to incorrect inferences that families matter more for women than for men or that large families experience more varied outcomes than small families.

In this paper, we report relationships between size of sibship and the effects of family background, gender, and gender composition on educational attainment. We use a model of sibling resembance in educational attainment which can be applied to a rare set of data on educational attainment among all siblings in a large sample of families, namely, those of a large family of Wisconsin high school graduates. Specifically, we ask whether family size interacts with the effects of other social background variables on the educational attainments of men and women, whether the effects of gender on educational attainment interact with family size, and whether there is more or less heterogeneity among educational attainments in larger or smaller families.

In an earlier paper, we developed a comprehensive model of family influences on educational resemblance of siblings, which expanded the traditional sibling pair model to a full sibship model; this permitted us to see how gender, gender composition of sibships, and a measure of ordinal position moderate the effect of family background on educational attainments of siblings. We estimated this model separately for three sizes of sibship (three, four and five), using full-sibship data from the Wisconsin Longitudinal Study. We found that one common family factor was sufficient both to mediate the effects of measured social background variables and to explain the covariation of educational attainment among brothers and sisters. Although effects of family background variables on brothers were larger than on sisters, the relative effects of measured family background variables were virtually the same among sisters and brothers. Brothers obtained more schooling than sisters, regardless of family size or gender composition. Within gender, ordinal position did not alter the effects of family background on educational attainment, nor did it directly affect educational attainment. Father's and mother's education were equally important for all siblings regardless of birth order, gender composition, or family size.

In the present study, we address several additional questions. Size of sibship has been relatively neglected in previous models of sibling resemblance in schooling. Some studies have not included it as a measure of social background (Benin and Johnson 1984, Hauser and Wong 1989), while other studies have included it as a background measure, but without any special attention to its signficance in family structure (Olneck 1976, Hauser and Sewell 1986, DeGraaf and Huinink 1992, Kuo and Hauser 1994). Kuo and Hauser (1993) analyzed data in full sibships separately for sizes three, four, and five, but they did not look closely at similarities and differences in the parameters of their models across family size. With the analytic framework developed by Kuo and Hauser (1993), we can look more closely at relationships between size of sibship, family background, and educational attainment. For example, among brothers and sisters in the Wisconsin sample, the unmeasured common family variances in schooling appear to vary inversely with size of sibship: 1.57 for size three, 1.42 for size four and 1.27 for size five. Also, the estimated means of siblings' schooling (13.20, 12.93 and 12.72 for sisters, and 13.77, 13.39, 13.05 for brothers in sibship sizes three, four, and five, respectively) show the expected effects of size. However, Kuo and Hauser (1993) did not test the differences in family heterogeneity by size of sibship, nor did they ask whether effects of sibship size interacted with gender. Here, we will look intensively for interactions between size of sibship and the effect of family background on educational attainment.

Size of Sibship and Educational Attainment

Size of sibship, sometimes unfortunately labelled "family size,"[1] has been studied as an aspect of social stratification and the sociology of family for decades. The inverse effect of size of sibship on educational attainment is well established. Indeed, there are well established relationships between size of sibship and many outcomes: intellectual development, academic achievement, educational attainment, occupational attainment, personality, mental health, fertility plans, parent-child interactions, family finances, and family contacts.

Blau and Duncan (1967) initiated research on the effects of family structure and configuration, including size of sibship, on socioeconomic attainment. They showed that, using the 1962 Occupational Changes in a Generation survey, the size of the parental family had an important influence on the son's education and subsequent career.[2] In later studies of status attainment and educational stratification, for example, Duncan, Featherman and Duncan (1972), Featherman and Hauser (1976), Hauser and Featherman (1976), Featherman and Hauser (1978), Mare (1980), Sewell, Hauser and Wolf (1980), Blake (1981), and Hauser and Sewell (1985), the negative relation between educational transition or completed schooling and size

[1] "Family size," properly measured, would presumably include parents and other related individuals whose presence may vary, while size of sibship -- an awkward term, to be sure, is better defined.

[2] Also, see Beverly Duncan (1967).

of sibship has generally been confirmed. However, Mare (1980) found that the negative effect of size of sibship diminished in later educational transitions and that given graduation from college, there was no relation between size of sibship and post-college attendance.

We may explain the relationship between size of sibship and education from several perspectives. It is known that mental ability has a positive effect on educational attainment, and size of sibship has a negative effect on mental ability. The relation between size of sibship and measured ability has been studied extensively. Earlier studies persistently confirmed the negative relation between size of sibship and mental ability, and later studies, controlling for family background, still found the negative effect (see review in Blake 1989). However, the negative effect of size of sibship on educational attainment remains after controlling measured ability, for example, Duncan, Featherman and Duncan (1972, p. 94-100). This finding was confirmed among female and male Wisconsin high school graduates by Sewell, Hauser, and Wolf (1980: 570-573), who also found that sibship size appeared to work through perceived encouragement from significant others and through educational and occupational aspirations. Other studies have also showed a negative relationship between size of sibship and educational ambitions and parental expectations for children's education (Hauser 1971; Blake 1989).

The dilution theory was proposed to explain the process how size of sibship influenced education. Lindert (1978) suggested that the negative effect of size of sibship on educational attainments resulted from the time and inputs children had received from their parents. The confluence model suggested that mental ability was a function of size of sibship, birth spacing, parent-child interactions and sibling interactions (Zajonc 1976), but most studies failed to verify the effect of birth order (Olneck and Bills 1979; Steelman 1985; Retherford and Sewell 1991). Blake (1981, 1989), incorporating children's aspiration into the dilution theory, argued that parental inputs affected children's perception of parental encouragement and parent-child interactions; children's perceptions and parent-child interactions affected children's educational attainment; and, thus, size of sibship affects children's educational attainment.

No doubt many intermediate factors help explain the negative effect of size of sibship on educational attainment. Blake (1989) presented an ambitious analysis of the relationship between size of sibship and achievement. She used several sets of American data to study, or more accurately, to confirm the relationship between size of sibship and education, educational aspiration, and ability. She not only studied the effect of size of sibship on education, but also on some personality traits, measured ability, and achievement aspirations, which could all be seen as intermediate variables in the relationship between educational attainment and size of sibship. In general, she found that the size of sibship had consistent negative effects on achievement and ability while the smallest families, such as only-child or two-child families, did not impoverish, as some stereotypes might suggest, the personality traits of offspring.

Some problems in Blake's analysis arose from the way she dealt with aggregate data and from inferences that could not properly be made from cross-sectional surveys like Occupational Change in a Generation. The latter are particularly relevant here. For example, the birth order effects should be examined in actual sibships, not by inference from unrelated respondents in cross-sectional surveys.. Theories of the effects of birth order focus on intra-familial processes, such as competition between siblings for family resources or teaching of younger siblings by older siblings. Survey-based comparisons of persons in different birth orders in different families obviously fail to control for unmeasured family differences, which may be confounded with birth order. The most obvious among these, perhaps, are size of sizship and socioeconomic status, yet it is well established that other inter-family differences figure prominently in educational attainment and other socioeconomic outcomes (Hauser and Featherman 1976, Kuo and Hauser 1994). In this regard, the analyses by Hauser and Sewell (1985) and Kuo and Hauser (1993, 1994) are better designed because they examine differences in outcomes within families.

Blake (1989:167,174) concluded that the WLS data for full sibships were "not well suited to the study of birth-order effects on education." Unfortunately, her discussion confounded the real selectivity of high school graduation by size of sibship with a grossly exaggerated account of the (historically determined) preponderance of sample members in lower birth orders. She claimed that the effect of size of sibship would be underestimated among respondents from the Wisconsin Longitudinal Study, who were all high school graduates, given that the size of sibship effect diminished in successive school transitions. However, the Wisconsin data also included all living siblings of respondents, who were selected only incidentally to the attainment of the primary respondents and who include a substantial number of high school dropouts. Moreover, Blake ignored simple corrections for selectivity that had been applied in the analysis that she rejected (compare Hauser and Sewell 1985).

Also, Blake argued that conventional socioeconomic origin variables and other unmeasured parental characteristics, which were associated with size of sibship, attenuated the effect of size of sibship; this argument would have no merit except to the degree that one could argue that other socioeconomic characteristics of the family of orientation were consequences of sibship size. Furthermore, by comparing the standardized coefficients of size of sibship with those of other family background characteristics from the regression analyses, she concluded that size of sibship had a more important effect than other family background variables (Blake 1989, p.49-55). One reason for this is that the number of a person's brothers and sisters can probably be ascertained more reliably, say, than her father's occupational status or mother's educational attainment. However, even more to the point, the more socioeconomic characteristics one enters, the more likely one would support Blake's argument, provided the joint influence of the socioeconomic variables were ignored. That is, the socioeconomic variables are more like one another than like sibship size, and the large effects of socioeconomic background tend to be split among the available indicators. However, despite the flaws of Blake's analysis, it remains inarguable that large sibships inhibit educational attainment.

Size of sibship, Family Configuration and Sibling Resemblance Models

Studies of sibling resemblance and differentiation can answer two kinds of questions (Sewell and Hauser 1977). First, researchers are interested in distinguishing variation within a family from variation between families; they study how much more siblings are similar to each other than to unrelated persons (Benin and Johnson 1984; Hauser and Wong 1989; DeGraaf and Huinink 1992). Second, researchers are interested in differences between siblings; they look at the influence of variables on which siblings do not have common values, for example, birth order, sex, and birth spacing (Adams 1972; Hauser and Sewell 1985; Retherford and Sewell 1991). Models of sibling resemblance address the first question while those of family configuration address the second.

The unit of analysis in the classical status attainment model is an individual in the general population (Blau and Duncan 1967), so the model cannot properly specify either within-family or between-family effects. For example, effects of birth order are typically estimated in samples of persons from different families, rather from the same family, so birth order may be confounded with other, between-family effects. In the Wisconsin Longitudinal Study (WLS), variations in educational attainment by birth order were far different in full sibships than among the original respondents who graduated from high school in 1957 (Hauser and Sewell 1985, pp. 9-11). At the same time, as noted by Bowles (1972), because individual data do not allow the complete specification of the relevant social background of individuals, estimates of the effects of schooling may be biased upward. That is, no matter how many social background variables -- paternal and maternal schooling, occupation, income, race, region, etc. -- one puts into a model, some relevant common family background factors are probably left out. By specifying one or more common, unmeasured family background factors, a model of sibling resemblance can meet this criticism.[3]

Moreover, family environment includes all elements of family configuration, but the limitation of analyses to sibling pairs ignores some possible effects, e.g., that of the gender composition of the sibship or those of specific positions in the birth order. When we use data for sibling pairs from sibships with different gender composition, the effect of gender is confounded with effects of other elements of family configuration. First, among randomly selected pairs of siblings, we cannot distinguish the effect of birth order from that of gender in a mixed-sex pair. Second, the likelihood of choosing a pair of brothers in a random sample is, of course, higher for families with sibships with more brothers, while the opposite holds true for sister pairs. Respondents from larger families are more likely to be drawn from a general population. Thus, differences among brother pairs, sister pairs, and brother-sister pairs may result from differences in size of sibship, from differences in the gender composition of sibships or from differences in ordinal position. In Kuo and Hauser (1993), we employed a data set with information on educational attainment in full sibships to model the resemblance among siblings and look for effects of family

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[3] However, such analyses do not eliminate the need to control common causes of schooling and its sequelae. For example, differences both in ability and motivation may occur within as well as between families and thus confound the within-family relationship between schooling and socioeconomic success.

configuration. However, we analyzed our models separately for each size, so effects of size of sibship on educational attainment of siblings and its interactions with other variables of family background and configuration were ignored.

Most of the studies of size of sibship and education use samples of individuals, rather than of siblings. Thus, they could only examine the effect of size of sibship on between-family variation in attainments. A few studies used sibling data to analyze the effect of family configuration, mainly of birth order. Lindert (1974) studied effects of size of sibship and birth order on socioeconomic achievements using a sample of 1,087 siblings collected in 1963; the study was limited by small and highly selective sample and lack of information on family background. Olneck and Bills (1979) used a sample of Kalamazoo brothers to study family configuration effects on ability test scores and socioeconomic achievements. Controlling family background, they found that the effect of size of sibship on schooling persisted. In the study, they used a square term of size, orthogonal to size, to capture the diminishing effect of size of sibship. And, this square term was not significant in equations for education after controlling socioeconomic background. The study was limited by, again, small and restricted sample, and lack of information on the sex and age composition. Hauser and Sewell (1985), using a sample of full sibship from Wisconsin Longitudinal Study and controlling sex, age, birth order and variables of family background, found a negative effect of size of sibship on schooling. They also found that size of sibship attenuated the effect of gender on education in sibships smaller than six. However, like Kuo and Hauser (1993), they did not pool all sizes of sibship together but had a separate regression equation for each size of sibship.

Yet, those studies and other sophisticated sibling resemblance models (for example, Hsueh 1992), mainly impaired by the small sample size, except for Hauser and Sewell (1985), did not take advantage of sibling data to study the relationships among size of sibship, other variables of family configuration and the effect of family background on educational attainment. In the current study, we intend to explore this subject with our model for full sibship data.

In the next section, we introduce the full sibship data from the Wisconsin Longitudinal Study and describe the variables used in the analysis. We first introduce the multiple-group, multiple-indicator-and-multiple-cause (MIMIC) model of sibling resemblance in schooling. We explain the method and techniques employed to combine data on families with different numbers of siblings – hence different numbers of variables (educational outcomes) -- within our structural model. We next explain our analytical strategies for studying the relationships between size of sibship and the effect of family background on educational attainment. We describe the earlier analyses and findings from Kuo and Hauser (1993). Finally, we report our new analyses, including model selection, estimates of parameters, decompositions of variance and estimated means, and we summarize our findings.

Data and Variables

The Wisconsin Longitudinal Study (WLS) began with a survey of all high school seniors in Wisconsin's class of 1957. Later, one third of the original respondents were selected at random for further study. In 1964, a brief follow-up was conducted by mailing parents a postcard questionnaire in order to update the social and economic situation of 1957 respondents. In 1975, the original respondents were interviewed by telephone in a second follow-up, which collected information about social background, occupation, education, marriage, children and social activities. Data on age, sex, and educational attainment were collected for all living siblings of the respondent. At the same time, one sibling was randomly selected from each full sibship roster. In 1977, a subsample of about 2,000 of the selected siblings were interviewed, using essentially the same questionnaire as in 1975. Most of the previous studies of sibling resemblance in the WLS have used only data for this subsample of sibling pairs (Hauser and Mossel 1985, 1987; Hauser 1984; Hauser 1988; Hauser and Wong 1989; Lee 1989). Hauser and Sewell (1985) used the WLS sibling rosters to study the effects of birth order on levels of educational attainment, but they did not attempt to model sibling resemblance. Kuo and Hauser (1993) used the rosters to develop a model of resemblance in full sibships and to investigate effects of family configuration. We use the WLS data here again because they include the age, sex, and attainment of all siblings of the primary respondents who were living in 1975.

Table 1 shows the distribution of sibship size and the gender composition of 9081 WLS respondents in the 1975 survey who reported their numbers of siblings.[4]

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[4] In this analysis, sibship size includes the respondent; it is one more than the respondent's number of brothers and sisters.

Ninety-two percent of respondents have one or more siblings. Almost three quarter of respondents with any siblings at all have one to four siblings; that is, seventy one percent of the sample is from sibships of size two, three, four, or five. Note that, even in sibships of five or six persons, the number of families (of original respondents) with all boys or all girls is quite small. We start the analyses with sibship size two.[5] Owing to the wide range of siblings' ages, we limit our analysis to sibships in which all brothers and sisters were aged twenty-two to fifty-five in 1975, when the original respondents were 36 years old. This limitation may eliminate some effects of wide birth spacing, but it also eliminates persons who probably had not completed their schooling or who were unlikely to be biological siblings of the original respondents. Finally, we have a sample of 1,874 sibships of size two, 1,790 sibships of size three, 1,178 sibships of size four, and 785 sibships of size five. These sibships include ninety-four percent of the original respondents in sibship size two, 90 percent in sibship size three, 81 percent in sibship size four, and 76 percent in

[5] In our earlier study, we start the analyses with sibship size three. This is the minimum sibship size needed to identify a two-factor model, and that is the reason we chose to limit our earlier work to sibship sizes greater than two. Given our failure to find a second family factor, we have included sibships of size two in the present analysis. See appendix B for analyses on the sample of size two. We did not have only-child respondents analyzed because the model of sibling resemblance required at least two educational outcomes. However, according to Hauser and Sewell (1985), only children (respondents) are not clearly advantaged or disadvantaged relative to other children from sibship size two. We did some exploratory analyses to compare personal characteristics of WLS respondents from sibship size one or two with those of respondents from larger families. The differences between size two and under and size three and above are significant; but, the differences between size two and one are insignificant. We have not included sibships of six or more in this analysis because of the small number of observations in many of the gender combinations.

sibship size five.

We have defined subgroups and endogenous variables for the analysis by size of sibship, by gender composition of the sibship, and by the arrangement of relative birth order within sex. We first group the sample by size of sibship. Then, we group the sample of each size by gender composition. Thus, there are three subgroups for sibship size two, four for sibship size three, five for sibship size four, and six for sibship size five. Next, we divide siblings in each group by sex, and within each sex, place them by ascending order of birth, i.e., from the oldest to the youngest. This arrangement appears on the right hand size of each of the path diagrams in Figure 2. For example, in a two-sister sibship of size four, the order is the oldest sister, the youngest sister, the oldest brother, and the youngest brother. Thus, our design does not identify effects of birth order, per se, but only of relative ordinal position within same-sex siblings, except in the case of all-female or all-male sibships. We use this simplified specification of birth order because of the very large number of possible combinations of birth order with gender composition. In our previous study of family configuration and gender, we found that relative birth order and gender composition do not alter the effect of family background on educational attainment of siblings for sibship size three, four and five. Here, we analyze the sample of size two as we have analyzed those of size three to five, merge the samples of all four sizes together and, thus, analyze data from eighteen groups defined by gender composition and size of sibship: five brothers, one sister, two sisters, three sisters, four sisters, and five sisters in sibships of size five; four brothers, one sister, two sisters, three sisters, and four sisters in sibships of size four; three brothers, one sister, two sisters, and three sisters in sibships of size three; and two brothers, one sister, and two sisters in sibships of size two.

Table 2 gives means and standard deviations of the measured endogenous variables, that is, the years of schooling of siblings, by size of sibship (vertical panel), gender (horizontal panels), and relative birth order (rows within horizontal panels). Thus, in all-brother sibships of size three, shown in the first column of the table, the mean years of schooling completed are 13.87 for first-born sons, 13.68 for second-born sons, and 13.62 for last-born sons. In sibships of the same size with one sister, the mean sister's education is 13.30 years, while the mean schooling levels are just below 14 years both for older and younger brothers; our design does not distinguish among the three possible ordinal positions of the sister in this configuration. Inspection of table 2 suggests the consistency of the data with previous findings: Siblings from smaller families finish more schooling, and within sibship sizes and configurations, men usually finish more schooling than women. Also, there is consistently less variability in the schooling of sisters than of brothers. There is no clear pattern to educational attainment by birth order or relative birth order, although there is a hint of a positive relationship between birth order and schooling among gender homogeneous sibships of size five. With one exception (in sibship size five), the education of sisters in families with only one daughter is larger than the education of sisters in all other sibling configurations of the same size, but this effect, if any, is quite small.

The exogenous variables include family income (in thousands of dollars), father's and mother's education (in years), father's occupational status (Duncan SEI score), Catholic upbringing, and farm background.[6] Unfortunately, our data do not include measured ability and educational aspiration for all of the members of each sibship, which mediate part of the effect of size of sibship on educational attainment.[7] Because of this omission, we can only obtain reduced form estimates of the effect of social background and size of sibship. These are likely to overestimate the direct effects of social background and sibship size and to overestimate the unmeasured between-family component of schooling. However, we can correctly estimate the relative importance of between- and within-family sources of variation in educational attainment.

Methods

Figure 2 displays the path diagram of the MIMIC model used in earlier sibling resemblance models (Hauser and Wong 1989). The general model is

$$\eta = \Gamma \xi + B \eta + \zeta \tag{1}$$

where η is the endogenous latent variable; ξ is a vector of exogenous latent variables with variance-covariance matrix Φ; ζ is a vector of disturbances, independent of η and ξ, with variance covariance matrix Ψ; Γ is a parameter matrix of effects of ξ on η;

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[6] We also report correlation matrices for all groups in Appendix A.

[7] We do have these data for two siblings in each of some 2000 pairs -- those for whom a sibling was interviewed in 1975 -- and with those data in hand, it might be possible to simulate the effects of sibship size through ability and aspiration in the full sibship data. However, we have not attempted that here.

and B is a parameter matrix of effects of η_2 on η_1. In general, the measurement models for the latent variables are

$$X = \Lambda_x \xi + \delta \tag{2}$$

and

$$Y = \Lambda_y \eta + \varepsilon \tag{3}$$

where X and Y are vectors of observable variables, i.e., indicators of ξ and η, respectively; Λ_x and Λ_y are parameter matrices giving the effects of ξ and η on X and Y, respectively; and Θ_δ and Θ_ϵ are the variances of δ and ϵ, respectively. In our specification, equation 2 is not shown in the diagram because we assume that each exogenous variable only has one indicator, all elements in Λ_x are equal to one and Θ_δ is equal to zero; that is, all ξs are perfectly measured by corresponding xs. Equations 3 and 1 in matrix form for sibship of size 4 are

$$\begin{bmatrix} y_1^g \\ y_2^g \\ y_3^g \\ y_4^g \end{bmatrix} = \begin{bmatrix} \lambda_{11}^g \\ \lambda_{21}^g \\ \lambda_{31}^g \\ \lambda_{41}^g \end{bmatrix} \begin{bmatrix} \eta_2^g \end{bmatrix} + \begin{bmatrix} \varepsilon_1^g \\ \varepsilon_2^g \\ \varepsilon_3^g \\ \varepsilon_4^g \end{bmatrix} \tag{4}$$

and

$$\begin{bmatrix} \eta_1^g \end{bmatrix} = \begin{bmatrix} \gamma_{11}^g & \gamma_{12}^g & \gamma_{13}^g & \gamma_{14}^g & \gamma_{15}^g & \gamma_{16}^g \end{bmatrix} \begin{bmatrix} x_1^g \\ x_2^g \\ x_3^g \\ x_4^g \\ x_5^g \\ x_6^g \end{bmatrix} \tag{5}$$

where x_1, ..., x_6 are the exogenous variables, y_1... y_4 are educational attainments of siblings, and the superscript g indicates groups defined by gender composition and size of sibship. In equation 4, $\lambda_{11} = 1$ is a normalizing constraint, so λ_{21}, λ_{31} and λ_{41} rescale the γ_{1j} to effects in the metric of y_2, y_3 and y_4, respectively.

Also, the relationship between η_2 and η_1 is

$$\eta_2^g = \beta_{21}^g \eta_1^g + \zeta_2^g \tag{6}$$

where the coefficient, β_{21}, may be used to specify differences among sizes of sibship in the global effect of family background on education, and the stochastic disturbance, ζ_2, represents unmeasured common family influences on the educational attainment of siblings. That is, in equation 6, when Γ and Λ_y are specified as invariant across sizes of sibship, the specification that $\beta_{21} = 1$ for size 5 and $\beta_{21} \neq 1$ for other sizes permits us to estimate overall differences among sibship size groups in the effect of family background; otherwise, $\beta_{21} = 1$ for all g. We specify no disturbance for η_1 in equation 5. It is actually a matter of indifference whether we permit the disturbance to appear in equation 5 or in equation 6, but only one such common variance term is identified.

The effects of family background variables on the educational attainment of each sibling in the constrained reduced form are the products of the corresponding γs and λs of Λ_y. By testing hypotheses on the equality of λ or γ between (or among) groups, we are studying the interaction between the effects of family background on education and group membership, i.e., size of sibship or gender composition. As stated before, one advantage of the sibling resemblance model is that we can study the variation of the unmeasured family component of educational attainment. As illustrated by Figure 2, ζ stands for the unmeasured but common family components or factors in the education of siblings, i.e., the co-variation of education among siblings that cannot be explained by the measured variables of family background. It can also be described as the unmeasured between-family (shared) variation. It may represent unmeasured family factors, for example, shared neighborhood, cultural environment, heredity, and educational aspiration. The εs stand for the variation of a sibling's education that cannot be explained by the common family factor (η); it is also known as the within-family (non-shared) variation, and represents uniquely individual family and schooling experiences, mental ability, educational aspiration, personal friends, and, probably, "luck." Note that the unmeasured within-family variance could also include measurement error, while – if measurement errors are random – the between-family (co)variance is unaffected by measurement error (Hauser and Mossel 1985). By estimating the measured or unmeasured between- and within-family variance components, we can analyze and compare the sources of variation in educational attainment.

Because sibships of different size necessarily yield different numbers of observations of educational attainment, there are different numbers of variables in the models for sibships of two, three, four, and five children. We used methods for the estimation of structural equation models with missing data that were introduced in Allison (1987) and Allison and Hauser (1991) to combine data for the three sizes of sibship. By combining equality constraints across subsamples with the introduction of null parameters for missing variables, multiple group models can be estimated simultaneously for groups defined by the presence or absence of certain observations.[8] That is, we introduce pseudo-values for the moments of missing variables and specify innocuous fixed values for their factor loadings and variances.

To elaborate, equation 4 for size four is re-parameterized as if

$$\begin{bmatrix} y_1^g \\ y_2^g \\ y_3^g \\ y_4^g \\ y_5^{g*} \end{bmatrix} = \begin{bmatrix} \lambda_{12}^g \\ \lambda_{22}^g \\ \lambda_{32}^g \\ \lambda_{42}^g \\ \lambda_{52}^{g*} \end{bmatrix} \begin{bmatrix} \eta_2^g \end{bmatrix} + \begin{bmatrix} \varepsilon_1^g \\ \varepsilon_2^g \\ \varepsilon_3^g \\ \varepsilon_4^g \\ \varepsilon_5^{g*} \end{bmatrix} \quad . \tag{7}$$

for $g = 7, \ldots, 11$ (the groups of size four), $\lambda_{51}^* = 0$ and $\theta_5^{\varepsilon^*} = 1$. The values of $\theta_5^{\varepsilon^*}$ and λ_{51}^* are arbitrary because the endogenous variable (y_5^*) has not been observed and the fixed values do not affect model fit or other parameter estimates. We make a corresponding adjustment in the groups with three siblings, adding two feigned endogenous variables and error terms. Finally, for size two, to make the structure parallel to size five, we add three feigned endogenous variables (y_3^*, y_4^*, y_5^*), and three error terms (ε_3^*, ε_4^*, ε_5^*) and assign the same arbitrary values to corresponding λ^* and θ^{ε^*} as in size four.

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[8] This treatment of missing moments is required within LISREL; other computer programs, for example, EQS, do not require this kind of model specification to estimate a model with missing variables.

So far, the structural model ignores the means of the variables; that is, we have ignored differences among and within sizes of sibship in mean levels of social background and in mean levels of attainment. We have also ignored differences in mean levels of attainment between brothers and sisters. In the earlier study, Kuo and Hauser (1993) found the expected, large differences in attainment by sex, but not by gender composition and relative birth order within the sibship size groups. Here, we are especially interested in difference in levels of attainment among the size groups.

To estimate the effects of latent variables on observable variables, we have to normalize one of the effects and estimate other effects in proportion to the normalized effect. Likewise, the mean of a latent variable is under-identified. However, we can estimate group differences in the means of latent variables, by normalizing one of the means as zero and estimating its difference from others.[9] The model is now defined by the equations:

$$\eta = \alpha + \Gamma \xi + B \eta + \zeta \tag{8}$$

$$y = \tau_y + \Lambda_y \eta + \varepsilon \tag{9}$$

Then, we can simplify equation 8 as follows:

$$\eta_2^g = \alpha_2^g + \beta_{21}^g \eta_1^g + \zeta_2^g \tag{10}$$

where α, τ_y are vectors of intercepts, and g indicates the groups. We ignore the equation in η_1 here because of (a later finding of) redundancy between η_1 and η_2.

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[9] Of course, this parallels the omission of one category of a string of dummy variables in ordinary regression analysis.

The expected values of y and η for the group, say k, are

$$E(y_s^k) = \tau_s^k + \lambda_s^k E(\eta_2^k) + E(\varepsilon_s^k) \tag{11}$$

$$E(y_b^k) = \tau_b^k + \lambda_b^k E(\eta_2^k) + E(\varepsilon_b^k) \tag{12}$$

and

$$E(\eta_2^k) = \alpha_2^k + \beta_{21}^k E(\eta_1^k) + E(\zeta_2^k) \tag{13}$$

where s and b indicate sisters or brothers. By assumption, $E(\varepsilon_s) = E(\varepsilon_b) = E(\zeta_2) = E(\zeta_1) = 0$. Further, since we have introduced an intercept for the latent family factor in the equation for η_2, we can say that $\beta_{21}E(\eta_1) = 0$, so for group k,

$$E(y_s^k) = \tau_s^k + \lambda_s^k \alpha_2^k \tag{14}$$

and

$$E(y_b^k) = \tau_b^k + \lambda_b^k \alpha_2^k \tag{15}$$

where λ_b is normalized to one. Also, for another group, say l, equations 14 and 15 are

$$E(y_s^l) = \tau_s^l + \lambda_s^l \alpha_2^l \tag{16}$$

and

$$E(y_b^l) = \tau_b^l + \lambda_b^l \alpha_2^l \tag{17}$$

Thus,

$$E(y_b^k) - E(y_b^l) = (\tau_b^k - \tau_b^l) + (\alpha_2^k - \alpha_2^l) \tag{18}$$

and

$$E(y_s^k) - E(y_s^l) = (\tau_s^k - \tau_s^l) + (\lambda_s^k\alpha_2^k - \lambda_s^l\alpha_2^l) \tag{19}$$

that is, the difference in expected values of siblings' education between two sizes of sibship is decomposed into two components: differences in the global mean levels of the latent factors and differences in means of the measured endogenous variables. However, we cannot determine both the means of the latent component and the measured component of the endogenous variables at the same time. If we assume that the unmeasured component is zero, we can estimate the observable component, and *vice versa*. Furthermore, there are two latent means in the unmeasured component. Even if we assume away the measured component, we can only estimate the difference between these two latent means. Substantively, by constraining both unmeasured components to be zero, we can test the null hypothesis that there is no effect of the group(s) on educational attainment; then, when we release the latent component, we estimate the global differences in educational attainment between the groups. Since Kuo and Hauser (1993) established that there were no group differences by gender composition, we focus here on those between sizes of sibship.

Overview of Analyses

To study the interactions between effects of size of sibship and family background, we first examine hypotheses related to effects of family background on educational attainments of siblings, such as effects of exogenous variables on the latent family factor (Γ), loadings of educational attainments of brothers and of sisters (Λ_y) on the latent family factor, the unmeasured between-family (Ψ) and within-family variances (Θ_ϵ), and the global effect of family background on the education of siblings for each size of sibship (B). Then, we test hypotheses related to means of endogenous variables, i.e., educational attainment of siblings; that is, we estimate the difference in educational attainment due to the variation in size of sibship. Table 3 reports goodness of fit statistics and model selection; table 4 reports estimates of effects of family background on educational attainments in our preferred model; the table 5 reports mean differences in educational attainment among brothers and sisters by size of sibship; and table 6 reports components of variance in the preferred model.

Baseline Model - Within Size Constraints

The baseline model permits no within-size variations in parameters. It is equivalent to the preferred models for size two in appendix A and the preferred models for size three, four and five in Kuo and Hauser (1993). Within each size of sibship, we equated the effect of the common factor (across gender composition and relative birth order, but not across gender) on attainments (Λ_y). We placed similar constraints on effects of measured exogenous variables on the common factor (Γ), the within-family variances of brothers and of sisters (Θ_ϵ), the unmeasured between-family variances (Ψ), and the means of the latent factor (α) and of endogenous and exogenous variables (τ) across groups. Thus, gender composition and relative birth order do not influence the effects of family background on the educational attainment of brothers or sisters for sizes two, three, four and five; the non-shared variances of education of brothers or sisters and the between-family variances of education of siblings do not differ among groups of gender composition; gender composition does not affect siblings' educational attainments; and father's education has the same effect on the educational attainment of brothers or sisters as does mother's education. However, we did not impose any gender equality constraints; sisters' educational attainment remains lower than brothers' educational attainment; sisters' attainments are less influenced by the common family factor; and there is less within-family variance in sisters' attainments. The goodness of fit statistics are χ^2 = 67.38 with 52 *df* for size two, χ^2 = 181.79 with 115 *df* for size three, 282.28 with 203 *df* for size four and 485.64 with 319 *df* for size five.[10]

Combining samples of the four sizes together, the goodness-of-fit statistic for the baseline model is χ^2 = 1017.08 with 689 *df*, which is identical to the sum of the fit statistics for sizes two, three, four and five. Note that in this model we do not impose any equality constraints across size of sibship, nor do we impose any equality constraints by gender. The latter constraint was rejected by Kuo and Hauser (1993), while the former is to be tested here.

Cross-Size Restrictions

In model 1 of table 3, we test the hypothesis that size of sibship does not alter the effect of the common family factor on educational attainment; literally, we impose

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[10] Nominally, we would reject each of these models, but we believe that the lack of fit is not substantively important. For example, this is indicated by large negative values of the Bayesian information criterion, *bic* (Raftery 1993): -265.61 in size two, -932.24 in size three, -1620.67 in size four, and -2405.64 in size five.

equality constraints on Λ_y across sizes of sibship for each gender. In other words, the model says that the difference in the effect of the common family factor on educational attainment between brothers and sisters persists over four sizes. However, since we have not placed any cross-size constraint on Γ, the model does not imply that the effects of social background are the same for women or for men across groups. The likelihood-ratio test statistic is χ^2 = 1020.02 with 692 *df.* Contrasted to the baseline model, with an increase of three *df*, χ^2 only increases by 2.94. We fail to reject the null hypothesis. That is, the relative effect of the common family factor on educational attainments of brothers and sisters does not vary with size of sibship.

Model 2 tests the hypothesis that, conditional on model 1, the within-family (non-shared) variance is not affected by size of sibship. The contrast between model 1 and model 2 yields χ^2 = 13.29 with an increase of six *df*, for which *bic* = -41.63. While the improvement in the likelihood ratio test statistic is of borderline statistical significance, the negative *bic* statistic leads us again to accept the null hypothesis.

In model 3, we impose equality constraints on Γ across sizes of sibship. This specification strengthens our general null hypothesis on the interaction between effects of size of sibship and the effect of family background on educational attainment of siblings. Model 3 states that size of sibship does not moderate the effect of each measured family background variable on educational attainment of siblings. The χ^2 statistic is 1053.89 with 713 *df.* Contrasted to model 2, the fit of model 3 is not significantly worse: With an increase of fifteen *df*, χ^2 increases by only

20.58. Thus, there is no interaction between size of sibship and the effects of family income, father's education, mother's education, father's SEI, farm background, or being a Catholic. Thus, model 3 says that the only variation in the effect of family background on educational attainment is due to the gender difference in the loadings of educational attainment on the common family factor. This fails to confirm Blake's (1985, p. 87, 1989) finding of an interaction between size of sibship and the effect of father's occupation on son's education.

In model 4, we consider a more parsimonious alternative than model 2 to the hypothesis that there is no cross-size variation in effects of social background variables. By permitting β_{21} to vary across groups (see equation 6), we specify that the global effect of the common family factor on education varies across sizes of sibship. That is, we allow the global effect of family background on education of siblings to vary by size of sibship while the effects of measured family background variables on the common family factor and the effects of the common family factor on brother's education or sister's education remain constant. In previous models, the β_{21}s are set to unity; in the present model, we release the constraints and maintain the unity constraint only on β^g_{21} while g = 1,...,6 (for size 5), but impose three sets of equality constraints, i.e., one on β^g_{21} while g = 7,...,11 (for size 4), one on β^g_{21} while g = 12,...,15 (for size 3), and the other on β^g_{21} while g = 16, 17, 18 (for size 2). That is, we estimate a proportional shift in the global effects of family background on education in sibships of size 4, size 3 and size 2, relative to the effect in sibships of size 5. This model does not fit better than the fully constrained alternative: χ^2 = 1048.23 with 710 *df.* With a decrease of three *df*, χ^2 only decreases by 5.66. Thus, we maintain the null hypothesis that there are no cross-size differences in effects of family background on attainment.

Conditioning on model 3, model 5 specifies that the unmeasured between-family variances do not differ by size of sibship; that is, all Ψs of size two, three, four and five are constrained to be equal. This constraint does not fit the data well; with an increase of three *df*, χ^2 increases by 29.98. The failure to accept this hypothesis implies that, although the effects of measured family background variables on educational attainments do not vary by size of sibship, the common, unmeasured between family variances do differ by size of sibship.

In the next two models, we estimate means of endogenous variables. In previous models, including the baseline model, all means of endogenous variables of brothers or of sisters are constrained to be equal across gender composition within each size of sibship, but means of brothers are different from those of sisters, and the mean levels of the latent common factors of education vary freely by size of sibship. Those models permit size of sibship to affect educational attainment and permit that effect to vary by gender. Model 6 conditions on model 3 and adds the specification that means of sisters are equal and that means of brothers are equal for all three sizes of sibship. That is, we impose equality constraints on τ_y across size groups for brothers and for sisters while the inequality between brothers and sisters remains. Since the effect of the common family factor on sisters' education is uniformly proportional to that on brother's education, model 6 also suggests that, regardless of size of sibship, group differences in means of educational attainment for women are constantly proportional to those for men, i.e., $[E(y_b^k) - E(y_b^l)]/[E(y_s^k) - E(y_s^l)] = 1/\alpha_s$. We do not prefer such a strong argument about the means of sisters or brothers, but, in order to estimate the global difference among groups, the specification is necessary to identify the difference among latent family factors.[11] The model fits poorly: χ^2 = 1268.03 with 719 *df*. Clearly, educational attainments of brothers and of sisters vary by size of sibship.

In model 7, we maintain the model specifications in model 6, but release the cross-size equality constraints on the mean levels of the latent common factors. That is, we allow differences in expected values of educational attainment of brothers or of sisters but force differences in the latent factors to be the same for men and women.[12] This implies that size differences in educational attainment, regardless of gender, can be summarized by global differences among sizes. Model 7 fits much better than model 6; χ^2 = 1066.70 with 716 *df*. That is, the expected values (means) of educational attainments of brothers or of sisters differ by size of sibship.

Model 7 allows non-linear differences in educational attainment between sibship sizes: the difference between size five and size four is 0.294, between size five and three is 0.660, and between size five and two is 1.085. We are interested in

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[11] If we release the constraints on the means of education (τ^y), we cannot identify the difference in mean levels of latent factor. See explanations in the method section.

[12] In fact, despite that we need setup of model 6 to identify the differences in educational attainment among sibship sizes of model 7, model 7 is still statistically and substantively nested to model 3.

whether the effect of sibship size is linear since most earlier studies have treated sibship size as a continuous variable. These differences appear close to linear, so we specify and test model 8, which forces the mean differences to be linear.[13] Model 8 fits the data very well: χ^2 = 1068.09 with 718 *df* and *bic* = -2640.25; in the contrast with model 7, χ^2 increases only by 1.39 with an increase of two *df*. We fail to reject this model. In sum, the expected values of educational attainments of siblings vary by sibship sizes and the distance between two consecutive sizes is constant for sibship sizes two to five in the WLS sample. We report the estimated means under this, our preferred model, in panel B of table 5, and we report the components of variance under this model in table 6.

Estimates of Parameters - Effects, Variances, and Means

Model 8 is our preferred model. In table 4, we report the effect of exogenous variables on the common family factor and the endogenous variables. The effect of family background on sisters is only eighty percent of the effect on brothers; thus, constrained by the single common family factor, the effects of observed family background variables on educational attainment of sisters are eighty percent of those on brothers. Family income, parental education, father's occupation (SEI), and farm background have positive effects on educational attainment of siblings, while being a Catholic has no significant effect. It is interesting that, controlling father's

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[13] We decompose these differences into three components and then test the equality hypothesis among them. That is, algebraically, say, the difference between size 5 and 4 is α'_1, between size 4 and 3 is α'_2 and between size 3 and 2 is α'_3; then, $\alpha_{size4} - \alpha_{size5} = \alpha'_1$, $\alpha_{size3} - \alpha_{size5} = \alpha'_1 + \alpha'_2$, and $\alpha_{size2} - \alpha_{size5} = \alpha'_1 + \alpha'_2 + \alpha'_3$. We test $\alpha'_1 = \alpha'_2 = \alpha'_3 = \alpha'$, i.e., $\alpha_{size4} - \alpha_{size5} = \alpha'$, $\alpha_{size3} - \alpha_{size5} = 2\alpha'$, and $\alpha_{size2} - \alpha_{size5} = 3\alpha'$.

occupational status (SEI), farm background has a large and significant positive effect on education of offspring.

Table 6 shows the variance components of the preferred model. Reading down the table, the first panel reports within-family variance (θ^{ϵ}), and its percentage of the total; the second panel reports unmeasured between-family variance (ψ); the third panel reports measured between-family variance; and the fourth panel reports all between-family variance, that is, the sum of its unmeasured and measured components.

We compare the variance components by gender and by the gender composition and size of sibships. We find that within-family variances are only about half as large among sisters as among brothers and that between-family variances almost always decrease as size of sibship increases. The inverse relationship between size of family and heterogeneity of schooling is partly a function of that relationship in the unmeasured between-family components of schooling, but a similar pattern appears also in the measured between family component of schooling, that is, the effects of measured social background. Although the inverse relationship between sibship size and heterogeneity pertains only to the between-family components of the variance in schooling -- since there are no family size differences in the within-family variance components of our preferred model -- this inverse relationship appears also in the overall relationship between heterogeneity and size of sibship. The total variances in educational attainment (not shown in the table) are 6.46 in sibships of size 2, 5.95 in size 3, 5.52 in size 4, and 4.90 in size 5.

Thus, the variance in educational attainment declines by just about 0.5 for each additional child in the range from 2 to 5 children per family.[14]

Since the effect of family background on the educational attainments of sisters is in the same propotion to that of brothers for all sizes of sibship, the ratio of between-family variances among sisters and brothers is just λ_s^{y2}, i.e., $(0.773)^2 = 0.598$ in model 8. Thus, the smaller variance in schooling among women than among men is explained by a weaker global effect of family background as well as by less variation in schooling within families.

The percentage distributions of variance components show that the share of within-family variance for sisters is smaller than for brothers in each family size, that is, ranging from 53.8 to 67.6 percent for sisters and from 56.0 to 71.5 percent for brothers, while the share of between-family variance for sisters is larger than for brothers, ranging from 32.4 to 46.2 percent for sisters and from 28.5 to 44.0 percent for brothers. Thus, among sisters, the variance of educational attainment owes relatively more to the shared common family factor than to the non-shared family factors while among brothers, the opposite holds true. Again, this finding about the relative importance of common and unique sources of variation does not contradict the greater influence both of family and non-family factors on the educational attainments of men. The relatively larger effect of common family background

[14] Note that the total variance in schooling among individuals depends on the distribution of children by gender within families and the gender difference in schooling as well as on the between- and within-family variance components that we have estimated.

among women is consistent with absolutely larger effects of the family among men.

Large size of sibship generally increases the share of variance determined by the within-family (non-shared) component. For sisters, the percentage ranges from 61.9 to 67.6 for size five, from 60.2 to 63.2 for size four, from 56.9 to 59.6 for size three and 53.8 and 54.1 for size two; for brothers, the percentage ranges from 64.0 to 71.5 for size five, from 62.3 to 67.9 for size four, from 59.1 to 61.8 for size three, and 56.0 and 56.3 for size two. However, this does not occur because of greater heterogeneity within larger families, but because of lesser heterogeneity among them. The within-family components of variance are constant across size of sibship, while the between-family components vary inversely with size.

Table 5 also reports estimated mean levels of education of brothers and of sisters, and the global differences in education among sizes. In model 8, which specifies additive effects of family size and gender, we find that the difference in attainment between size two and three, between size three and four, and between size four and five are 0.364 (0.026). That is, when the size of sibship increases from three to four, the average years of schooling of siblings decrease by .364 and when the size increases from three to five, the average years of schooling decrease by .728 = .364 × 2. The mean schooling levels among men and women differ by 0.422 in each sibship size: in sibships of five, the average years of schooling are 13.077 for brothers and 12.655 for sisters. That is, if an extra boy was born to a family with two children already, regardless of gender composition, he would be expected to obtain an education of 13.805 years, but if the extra child is a girl, she would be expected to obtain an education of only 13.483 years. If the extra boy was born to a family with three children already, he would be expected to obtain an education of 13.441 years, but, if the extra child is a girl, she would be expected to obtain an education of 13.019 years. If the extra boy was born to a family with four children already, he would be expected to obtain an education of average 13.077 years, but if the extra child is a girl, she would be expected to obtain an education of 12.655 years. If a girl were born to a family with one child less than her actual family, this would just about offset the disadvantage of being a girl; regardless of gender, one more sibling would lower the expected years of schooling by 0.364.[15]

Discussion

By pooling data for sibships of sizes two to five, we have examined the effects of size of sibship on the process of educational attainment in a model of attainment for full sibships. We found that, in general, size does not moderate the effect of family background on educational attainment. However, both measured and unmeasured between-family variance components vary inversely with size. Within-family variance is larger among men than among women, but it does not vary by size of sibship. Thus, the share of all between-family variance decreases by size and that of within-family variance increases by size. From the latter finding, one might argue that the educational achievement of children from large families is more determined by the resources obtained from non-shared family factors, but that would

[15] If we constrain the effect of gender to equal the effect of an additional child, χ^2 increases by 1.37 with 1 *df*. Thus, there is no significant difference between the effects of gender and of size of sibship.

be incorrect, because the importance of non-shared factors is invariant to size of sibship. Moreover, the greater importance of family circumstances among smaller families is not a consequence of larger effects of social background in those families, but of their greater heterogeneity, both in unmeasured and measured sources of educational attainment; we have found no differences in the effects of family background variables by size of sibship. These findings disconfirm Blake's argument that society is more open to people from small families than those from large families. There is no evidence of interaction between size of sibship and the effect of socio-economic origin on educational attainment of offspring, and smaller families are actually more heterogeneous than large families.

This is not to say that small families are disadvantageous. Our estimates of differences in mean levels of education provide clear evidence of the advantage conferred by smaller families, and these effects are linear in the WLS data (in the range from two to five siblings).

Within families, gender is the main factor (among those considered here) that differentiates educational attainment. Gender composition of sibships and relative birth order have no effects on educational attainment, nor do these factors interact with size of sibship, either with respect to mean levels of schooling or the effects of social background on schooling. Also, Hauser and Sewell (1985) have shown that the overall birth order has no effect. In the WLS cohorts, the disadvantage of being a woman was somewhat larger than that of adding another child to the family, and this effect of gender on educational attainment persists through all sizes of sibship, birth order, and gender composition. With respect to the sources of variation in schooling, our findings about women parallel those about family size. Family differences are relatively more important in schooling among women than among men, but this is artifactual. The effects of measured and unmeasured common and within-family sources of variation in schooling are larger among men than among women, but the within-family variation in schooling is much smaller among women than among men. Family effects appear relatively larger among women than men, even though the effects are larger, absolutely, among men.

Regarding size of sibship, with findings from size two, three, four and five, we obviously cannot draw general conclusions, nor do our findings necessarily hold for the recent period in which educational attainments of women have caught up with or exceeded those of men. It will be even more interesting to develop similar models for family effects in recent cohorts, as it will be possible to do with data from the National Longitudinal Survey of Youth and from the 1994 General Social Survey.

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Table 1. Distribution of Sibship Size and Gender Composition: Wisconsin Longitudinal Study

Sibship Size	1	2	3	4	5	6	7+	Total
Number of Sisters								
0	320	425	241	105	29	19	15	1154
	46.9	21.3	12.1	7.2	2.8	2.8	1.2	12.7
1	362	1051	742	367	169	67	41	2799
	53.1	52.6	37.3	25.2	16.4	9.8	3.3	30.8
2		522	772	542	321	154	122	2433
		26.1	38.8	37.1	31.1	22.4	9.9	26.8
3			233	368	313	191	243	1348
			11.7	25.2	30.3	27.8	19.7	14.8
4				77	169	170	305	721
				5.3	16.4	24.8	24.7	7.9
5					31	73	256	360
					3.0	10.6	20.7	4.0
6+						12	254	266
						1.7	20.6	2.9
Total	682	1998	1988	1459	1032	686	1236	9081
	7.5	22.0	21.9	16.1	11.4	7.6	13.6	100.0

Table 2. Descriptive Statistics of Variables

Sibship Size	Two			Three				Four					Five					
Group	16	17	18	12	13	14	15	7	8	9	10	11	1	2	3	4	5	6
Endogenous Variables(Years of Schooling)																		
Sister 1		13.47	13.39		13.30	13.11	13.12		13.08	12.93	12.90	12.76		12.94	12.62	12.82	12.51	12.37
		(2.15)	(2.13)		(2.02)	(2.05)	(2.05)		(2.04)	(2.11)	(2.07)	(2.01)		(1.87)	(1.93)	(2.01)	(1.87)	(1.92)
Sister 2			13.42			13.21	13.06			13.00	12.81	12.86			12.90	12.90	12.58	12.56
			(2.09)			(2.09)	(2.08)			(1.88)	(2.12)	(1.91)			(1.83)	(2.00)	(1.94)	(1.60)
Sister 3							13.17				12.95	12.70				12.87	12.65	12.74
							(2.12)				(1.91)	(1.63)				(1.87)	(1.93)	(1.61)
Sister 4												12.90					12.72	13.04
												(1.65)					(1.75)	(1.93)
Sister 5																		12.63
																		(1.76)
Brother 1	14.36	14.27		13.87	13.96	13.61		12.94	13.45	13.36	13.39		12.27	12.55	13.01	13.18	13.13	
	(2.89)	(2.88)		(2.94)	(2.86)	(2.71)		(2.17)	(2.70)	(2.79)	(2.57)		(2.90)	(2.54)	(2.82)	(2.64)	(2.37)	
Brother 2	14.49			13.68	13.95			12.97	13.65	13.46			12.73	12.95	12.90	13.53		
	(2.82)			(2.76)	(2.63)			(2.33)	(2.84)	(2.59)			(2.25)	(2.29)	(2.32)	(2.46)		
Brother 3				13.62				13.56	13.41				12.59	13.23	13.22			
				(2.37)				(2.65)	(2.30)				(2.46)	(2.44)	(2.25)			
Brother 4								13.10					12.91	13.22				
								(2.66)					(2.39)	(2.44)				
Brother 5													13.55					
													(1.99)					
Exogenous Variables																		
Income	6.41	6.95	6.83	5.84	6.52	6.18	6.14	5.62	6.03	5.88	5.91	5.76	4.95	5.05	5.31	5.39	5.84	4.86
	(3.47)	(3.58)	(3.60)	(2.88)	(3.36)	(3.31)	(3.17)	(2.92)	(3.33)	(3.33)	(3.15)	(2.71)	(2.16)	(3.17)	(3.04)	(2.95)	(3.35)	(2.38)
Father's Occupation	3.88	4.03	4.15	3.49	3.96	3.65	3.59	3.08	3.54	3.23	3.46	3.58	2.32	3.21	3.16	3.14	3.14	2.58
	(2.43)	(2.41)	(2.39)	(2.28)	(2.49)	(2.38)	(2.17)	(1.78)	(2.35)	(2.21)	(2.28)	(2.24)	(1.17)	(2.16)	(2.27)	(2.25)	(2.22)	(1.80)
Father's Education	10.39	10.42	10.35	9.87	10.36	10.16	9.86	9.17	9.75	9.50	9.75	9.35	8.32	9.41	9.02	9.47	9.50	9.67
	(3.38)	(3.39)	(3.49)	(3.42)	(3.55)	(3.40)	(3.15)	(2.86)	(3.65)	(3.37)	(3.24)	(3.21)	(2.19)	(3.51)	(3.27)	(3.36)	(3.50)	(3.20)
Mother's Education	10.92	11.01	10.82	10.72	10.93	10.66	10.28	10.00	10.60	10.39	10.29	10.54	9.50	10.13	10.09	10.45	10.03	9.78
	(2.89)	(2.84)	(2.74)	(2.63)	(2.75)	(2.90)	(2.70)	(2.77)	(2.81)	(2.86)	(2.69)	(2.42)	(3.02)	(3.14)	(2.80)	(2.64)	(2.79)	(2.22)
Catholic	0.37	0.34	0.34	0.39	0.38	0.38	0.41	0.52	0.43	0.45	0.41	0.48	0.50	0.37	0.47	0.45	0.49	0.56
	(0.48)	(0.47)	(0.48)	(0.49)	(0.49)	(0.49)	(0.49)	(0.50)	(0.50)	(0.50)	(0.49)	(0.50)	(0.51)	(0.48)	(0.50)	(0.50)	(0.50)	(0.51)
Farmer	0.15	0.13	0.11	0.19	0.15	0.18	0.16	0.23	0.20	0.20	0.21	0.19	0.23	0.29	0.26	0.23	0.23	0.26
	(0.36)	(0.34)	(0.31)	(0.39)	(0.36)	(0.38)	(0.37)	(0.42)	(0.40)	(0.40)	(0.41)	(0.40)	(0.43)	(0.46)	(0.44)	(0.42)	(0.42)	(0.45)

Table 3. Goodness of Fit Statistics, (n=3853)

	Model		χ^2/df		contrast		*bic*
0.	Baseline Model		1017.08	689			-2527.68
1.	0 +	equality constraints on Λ_y across size	1020.02	692	2.94	3	-2543.86
2.	1 +	equality constraints on Θ_ε across size	1033.31	698	13.29	6	-2565.49
3.	2 +	equality constraints on Γ across size	1053.89	713	20.58	15	-2623.93
4.	3 -	equality constraints on β across size	1083.87	716	-5.66	-3	-2613.78
5.	3 +	equality constraints on Ψ across size	1048.23	710	29.98	3	-2609.75
6.	3 +	equality constraints on τ_y across size	1268.03	719	214.14	6	-2444.72
7.	6 -	equality constraints on α across size	1066.70	716	-201.33	-3	-2620.24
8.	7 +	linear hypothesis on α	1068.09	718	1.39	2	-2640.25

Table 4. Parameter Estimates, Model 8 (Preferred Model)

	Coefficients		Total Effects			
Variables	λ^y/γ	s.e.	Sisters	s.e.	Brothers	s.e.
The Common Factor on Endogenous Variables						
Education of Brothers (λ^y)	1.000					
Education of Sisters (λ^y)	0.773	(.018)				
Exogenous Variables on the Common Factor						
Family Income (γ)	0.105	(.009)	0.081	(.009)	0.105	(.007)
Father's Education (γ)	0.124	(.005)	0.096	(.005)	0.124	(.004)
Mother's Education (γ)	0.124	(.005)	0.096	(.005)	0.124	(.004)
Father's Occupation (SEI) (γ)	0.158	(.014)	0.122	(.014)	0.158	(.010)
Farm Background (γ)	0.283	(.068)	0.219	(.068)	0.283	(.053)
Catholics (γ)	-0.030	(.048)	-0.023	(.048)	-0.030	(.037)

Table 5. Estimated Means and Standard Deviations, Model 8 (Preferred Model)

Variables	Size 5 Mean	Size 5 S.D.	Size 4 Mean	Size 4 S.D.	Size 3 Mean	Size 3 S.D.	Size 2 Mean	Size 2 S.D.
Family Background Variables (τ^x)								
Family Income	5.181	(.101)	5.904	(.087)	6.248	(.073)	6.784	(.081)
Father's Education	9.143	(.111)	9.585	(.090)	10.163	(.075)	10.379	(.078)
Mother's Education	10.136	(.094)	10.416	(.076)	10.729	(.063)	10.924	(.064)
Father's Occupation (SEI)	2.965	(.071)	3.366	(.060)	3.728	(.053)	4.022	(.054)
Farm Background	0.256	(.015)	0.202	(.012)	0.169	(.009)	0.130	(.008)
Catholic	0.441	(.017)	0.444	(.014)	0.382	(.011)	0.350	(.011)
Latent Common Factor (α)								
	0		0.364	(.026)	0.364	(.026)	0.364	(.026)
Educational Attainment (Years of Schooling, τ^y)								
Brothers	13.077	(.053)	13.077	(.053)	13.077	(.053)	13.077	(.053)
Sisters	12.655	(.041)	12.655	(.041)	12.655	(.041)	12.655	(.041)

Table 6. Decomposition of Variance, Model 8 (Preferred Model)

Groups	Variance Component								Percentage of Variance (%)							
	Size = 5		Size = 4		Size = 3		Size = 2		Size = 5		Size = 4		Size = 3		Size = 2	
	Sis	Bro	Sis	Bro	Sis	Bro	Sis	Bro	Sis	Bro	Sis	Bro	Sis	Bro	Sis	Bro
Within-Family Variance (θ^{ϵ})																
NSis = 0		4.409		4.409		4.409		4.409		71.5		67.9		61.8		56.3
NSis = 1	2.409	4.409	2.409	4.409	2.409	4.409	2.409	4.409	63.2	65.2	60.2	62.3	56.9	59.1	53.8	56.0
NSis = 2	2.409	4.409	2.409	4.409	2.409	4.409	2.409		64.4	66.5	61.1	63.2	57.7	59.7	54.1	
NSis = 3	2.409	4.409	2.409	4.409	2.409				63.1	65.2	61.8	63.9	59.6			
NSis = 4	2.409	4.409	2.409						61.9	64.0	63.2					
NSis = 5	2.409								67.6							
Unmeasured Between-Family Variance (ψ)																
NSis = 0		1.272		1.427		1.737		2.171		20.6		22.0		24.3		27.7
NSis = 1	0.760	1.272	0.853	1.427	1.038	1.737	1.297	2.171	19.9	18.8	21.3	20.2	24.5	23.3	29.0	27.6
NSis = 2	0.760	1.272	0.853	1.427	1.038	1.737	1.297		20.3	19.2	21.6	20.5	24.9	23.5	29.1	
NSis = 3	0.760	1.272	0.853	1.427	1.038				19.9	18.8	21.9	20.7	25.7			
NSis = 4	0.760	1.272	0.853						19.5	18.5	22.4					
NSis = 5	0.761								21.3							
Measured Between-Family Variance ($(\lambda^{\gamma})^2(\sigma^2_{\eta} - \psi)$)																
NSis = 0		0.489		0.654		0.994		1.258		7.9		10.1		13.9		16.1
NSis = 1	0.644	1.078	0.741	1.240	0.784	1.312	0.773	1.293	16.9	15.9	18.5	17.5	18.5	17.6	17.3	16.4
NSis = 2	0.570	0.954	0.681	1.141	0.728	1.236	0.750		15.2	14.4	17.3	16.4	17.4	16.7	16.8	
NSis = 3	0.648	1.084	0.635	1.064	0.597				17.0	16.0	16.3	15.4	14.8			
NSis = 4	0.722	1.208	0.551						18.6	17.5	14.5					
NSis = 5	0.396								11.1							
All Between-Family Variance ($(\lambda^{\gamma})^2(\sigma^2_{\eta})$)																
NSis = 0		1.761		2.081		2.731		3.429		28.5		32.1		38.2		43.7
NSis = 1	1.404	2.350	1.594	2.667	1.822	3.049	2.070	3.464	36.8	34.8	39.8	37.7	43.1	40.9	46.2	44.0
NSis = 2	1.330	2.226	1.534	2.568	1.766	2.973	2.047		35.6	33.5	38.9	36.8	42.3	40.3	45.9	
NSis = 3	1.408	2.356	1.488	2.491	1.635				36.9	34.8	38.2	36.1	40.4			
NSis = 4	1.482	2.480	1.404						38.1	36.0	36.8					
NSis = 5	1.157								32.4							

Figure 1.
Variable Description

Variable[1]	Source	Description[2]
Offspring's Education	CFOED1, CFOED2, CFOED3, CFOED4. and CFOED5; 1975 survey.	Years of school completed
Family Income	Constructed Variable. (BMPIN2) Taking information from Wisconsin tax data (PI5760) first; if not avaialbe, taking from 1975 report (YFML57).	per $100. Truncated at $15,000. Best Measure of Parental Income 1957.
Father's Occupation	Constructed Variable. (BMFOC1) Taking from 1975 report (OCSH57) first; if not available, taking from 1957 report (OCSF57).	Duncan Scores Best measure of Household Head's Occupation
Father's Education	Constructed variable. (BMFAED) Taking from 1975 report (EDHHYR) first; if not available, taking from 1957 report (EDFA57).	Years of School Completed Best Measure of Father's Education
Mother's Education	Constructed variable. (BMMAED) Taking from 1975 report (EDMOYR), first; if not available, taking from 1957 report (EDMO57). (BMMAED)	Years of School Completed Best Measure of Mother's Education
Catholic	Recoded variable from RELFML (1975 survey).	1: Catholic (1, 2 and 3 in RELFML); 0: otherwise.
Farmer Background	Recoded variable from OCMH57 (1957 survey).	1: Farmer/farm managers/farm laborers and foremen (16 and 17 in OCMH57); 0: otherwise.

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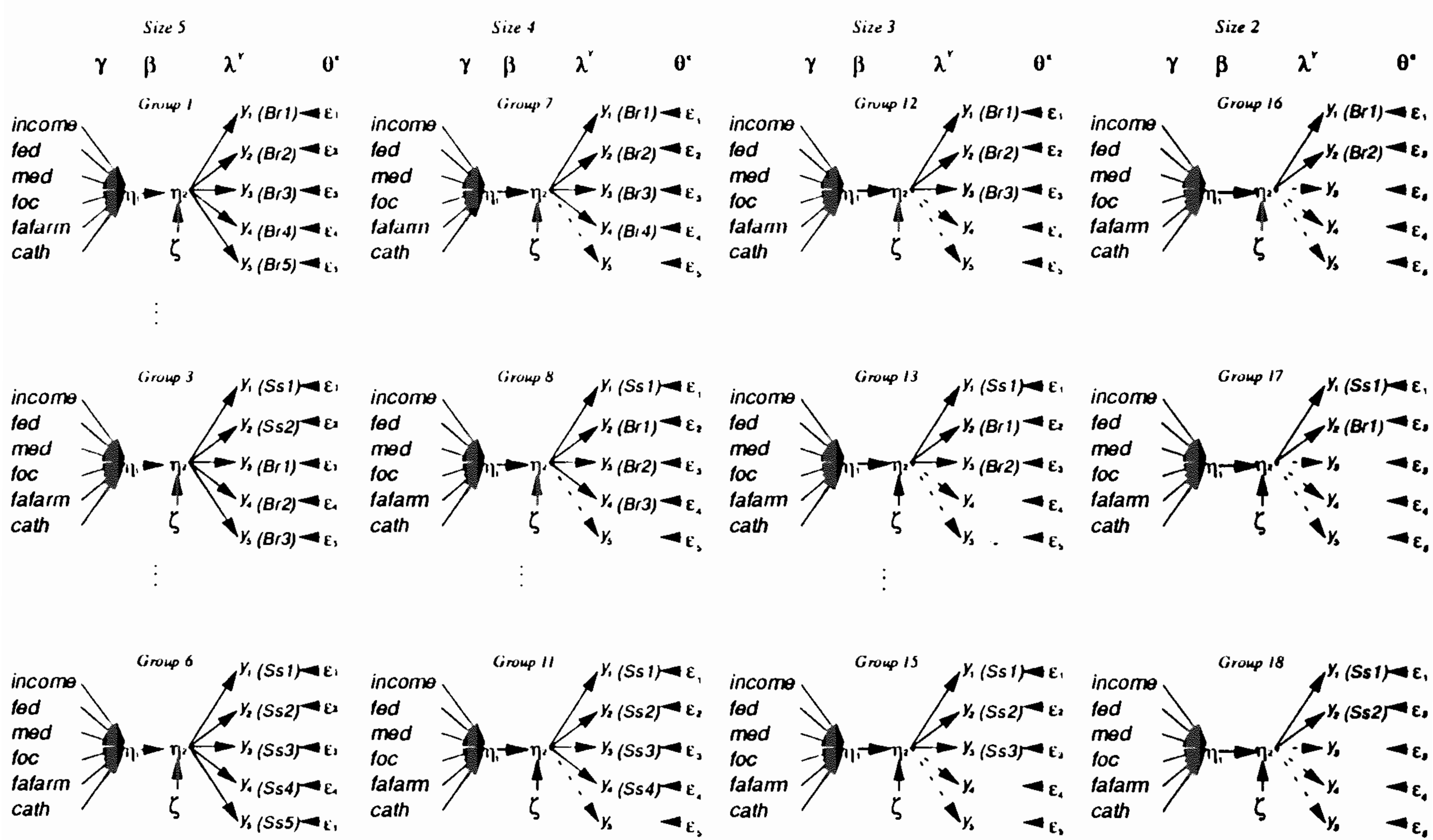
[1]Variables are in the order of correlation matrix (Appendix A.)

[2]See Table 2 for Standard Deviation and Mean.

Figure 2. The Sibling Resemblance Model for Sibships of Sizes 2 to 5



Appendix A. Correlation Matrices

Group 1, Size 5, all brothers

M1ED	M2ED	M3ED	M4ED	M5ED	BMPIN2	BMFOC1	BMFAED	BMMAED	CATH	FAFAM
1.0000										
.8078	1.0000									
.5503	.4344	1.0000								
.4715	.4204	.7787	1.0000							
.2615	.4593	.4842	.4909	1.0000						
.5041	.2151	.3980	.2681	-.0892	1.0000					
.2344	.2365	.3713	.3083	.5884	-.0049	1.0000				
.4958	.2309	.4844	.5973	.1874	.3781	.2167	1.0000			
.1687	-.0561	.2081	.2971	.1978	.1075	.3665	.4427	1.0000		
-.1284	-.2067	-.0567	.1558	-.4201	.2416	-.3253	.1487	.0462	1.0000	
.1393	.2153	-.1332	-.1648	.0152	-.1633	-.4351	-.2833	-.0551	-.3254	1.0000

Group 2, Size 5, one sister

F1ED	M1ED	M2ED	M3ED	M4ED	BMPIN2	BMFOC1	BMFAED	BMMAED	CATH	FAFAM
1.0000										
.4226	1.0000									
.3500	.2342	1.0000								
.3297	.2867	.3353	1.0000							
.3819	.4308	.2503	.3875	1.0000						
.1755	.2900	.3072	.2699	.2436	1.0000					
.1754	.2012	.1038	.3068	.2579	.5456	1.0000				
.2734	.1891	.2834	.2782	.1871	.2914	.3807	1.0000			
.2634	.1824	.2365	.2772	.1417	.2693	.2444	.4916	1.0000		
-.1290	.0215	-.0895	-.0988	-.1356	-.0329	.0733	-.0345	-.1340	1.0000	
.0031	-.2075	-.0761	-.1375	-.1214	-.3638	-.5453	-.3021	-.1946	-.2114	1.0000

Group 3, Size 5, two sisters

F1ED	F2ED	M1ED	M2ED	M3ED	BMPIN2	BMFOC1	BMFAED	BMMAED	CATH	FAFAM
1.0000										
.3707	1.0000									
.3702	.3637	1.0000								
.3246	.4071	.5417	1.0000							
.2533	.2986	.3159	.4479	1.0000						
.2551	.2640	.3015	.3257	.2704	1.0000					
.3085	.2173	.2209	.2342	.2780	.4699	1.0000				
.3604	.2365	.3423	.3590	.2989	.3292	.4721	1.0000			
.2680	.1355	.2181	.2049	.2597	.1274	.1736	.4563	1.0000		
.1238	.0705	.0877	.0540	.1518	.2125	.0984	.0955	-.0833	1.0000	
-.1331	-.0412	-.1208	-.0884	-.1596	-.3578	-.4674	-.2395	-.1028	-.1352	1.0000

Group 4, Size 5, three sisters

F1ED	F2ED	F3ED	M1ED	M2ED	BMPIN2	BMFOC1	BMFAED	BMMAED	CATH	FAFAM
1.0000										
.3789	1.0000									
.3909	.5228	1.0000								
.2880	.3064	.3436	1.0000							
.1291	.2705	.3093	.2417	1.0000						
.2137	.2657	.2262	.2616	.1386	1.0000					
.2266	.2931	.2944	.3933	.2637	.4485	1.0000				
.2390	.2769	.2846	.2792	.2933	.3795	.5125	1.0000			
.3063	.3495	.3376	.2643	.2195	.3629	.3507	.5116	1.0000		
.0534	.0316	.1270	.0931	.1692	.1639	.1648	.0773	-.0084	1.0000	
-.0217	-.0477	-.0559	-.1659	-.1244	-.2795	-.4269	-.1552	-.0147	-.1027	1.0000

Group 5, Size 5, four sisters

F1ED	F2ED	F3ED	F4ED	M1ED	BMPIN2	BMFOC1	BMFAED	BMMAED	CATH	FAFAM
1.0000										
.4751	1.0000									
.3524	.3664	1.0000								
.3004	.4880	.3576	1.0000							
.4392	.4381	.3993	.3765	1.0000						
.3004	.4867	.2561	.4847	.2898	1.0000					
.2945	.4178	.3232	.4514	.3417	.6088	1.0000				
.4234	.3885	.3149	.3888	.3119	.3866	.5436	1.0000			
.4489	.4046	.2328	.4189	.3196	.3587	.3507	.4615	1.0000		
-.0447	.0611	.0143	.1213	-.0132	.0077	.0400	.0790	-.0569	1.0000	
-.0554	-.1847	-.0226	-.1135	-.1812	-.4380	-.4414	-.1923	-.1327	.0880	1.0000

Group 6, Size 5, five sisters

F1ED	F2ED	F3ED	F4ED	F5ED	BMPIN2	BMFOC1	BMFAED	BMMAED	CATH	FAFAM
1.0000										
.7045	1.0000									
.4301	.6259	1.0000								
.4205	.4657	.7962	1.0000							
.0649	.1169	.5093	.5142	1.0000						
.1437	.1900	.0410	.1081	-.0885	1.0000					
-.0050	.3442	.2527	.0417	.4146	.0443	1.0000				
.0833	.3229	.2892	.1142	.0046	.3979	.5161	1.0000			
.1278	.2735	.1769	.2258	.2143	.1409	.3672	.4541	1.0000		
-.0219	-.1581	-.0053	.0175	-.1489	-.0998	-.0518	.0475	-.3301	1.0000	
-.2055	-.3167	-.2778	-.1900	-.0200	-.4547	-.3958	-.3949	-.2108	-.1512	1.0000

Group 7, Size 4, all brothers

M1ED	M2ED	M3ED	M4ED	nonED	BMPIN2	BMFOC1	BMFAED	BMMAED	CATH	FAFAM
1.0000										
.3641	1.0000									
.2784	.1404	1.0000								
.1524	.1573	.2143	1.0000							
0	0	0	0	1						
.1529	.2425	.3460	.0760	0	1.0000					
.2088	.2349	.2180	.2113	0	.3032	1.0000				
.2299	.0775	.0898	.2292	0	.1005	.2589	1.0000			
.2053	.1092	.0944	.1072	0	.0707	.4514	.3726	1.0000		
.0070	-.0974	.0267	.0443	0	-.1356	-.0311	.0743	-.2575	1.0000	
-.0380	-.1430	-.0182	.0125	0	-.3317	-.5225	-.1650	-.2943	.0600	1.0000

Group 8, Size 4, one sister

F1ED	M1ED	M2ED	M3ED	nonED	BMPIN2	BMFOC1	BMFAED	BMMAED	CATH	FAFAM
1.0000										
.3195	1.0000									
.3993	.4419	1.0000								
.3139	.3539	.4594	1.0000							
0	0	0	0	1						
.2461	.3335	.1941	.2074	0	1.0000					
.2991	.3816	.3322	.3492	0	.5526	1.0000				
.3188	.3416	.3571	.3940	0	.4045	.5335	1.0000			
.3450	.2916	.3229	.2537	0	.2472	.3269	.4614	1.0000		
-.0547	.0974	.0670	.0648	0	.1272	.1198	.0688	-.0866	1.0000	
-.1048	-.1865	-.0820	-.1472	0	-.3574	-.4561	-.2471	-.0799	-.1886	1.0000

Group 9, Size 4, two sisters

```
 F1ED F2ED M1ED M2ED nonED BMPIN2 BMFOC1 BMFAED BMMAED CATH FAFAM
1.0000
 .4016 1.0000
 .4046  .3817 1.0000
 .3572  .3778  .3677 1.0000
0     0      0      0     1
 .2442  .2879  .2903  .2620 0 1.0000
 .2305  .3479  .3616  .3094 0  .5478 1.0000
 .2783  .3147  .3220  .2441 0  .3751  .5302 1.0000
 .2945  .2129  .2997  .2125 0  .2818  .3185  .4465 1.0000
 .0359  .0679  .1435  .0425 0  .1579  .1515  .0739 -.0715 1.0000
 .0187 -.0813 -.1731 -.1645 0 -.3146 -.4101 -.2466 -.0693 -.1485 1.0000
```

Group 10, Size 4, three sisters

```
 F1ED F2ED F3ED M1ED nonED BMPIN2 BMFOC1 BMFAED BMMAED CATH FAFAM
1.0000
 .3300 1.0000
 .3146  .4102 1.0000
 .4053  .3309  .3046 1.0000
0      0      0      0      1
 .4122  .3217  .2335  .3272 0 1.0000
 .3173  .1940  .1894  .2625 0  .5210 1.0000
 .3952  .3467  .2499  .4019 0  .3602  .4707 1.0000
 .3374  .3400  .2741  .3456 0  .3325  .2838  .5050 1.0000
 .0061  .0746  .0529  .0389 0  .1370  .0280 -.0082 -.0188 1.0000
-.0786 -.0668 -.0551 -.1619 0 -.3867 -.4656 -.2032 -.0909 -.0413 1.0000
```

Group 11, Size 4, four sisters

```
 F1ED F2ED F3ED F4ED nonED BMPIN2 BMFOC1 BMFAED BMMAED CATH FAFAM
1.0000
 .5031 1.0000
 .3457  .5607 1.0000
 .1917  .2769  .3956 1.0000
0      0      0      0      1
 .2401  .1581  .1739  .1430 0 1.0000
 .3863  .2722  .2700  .4383 0  .5834 1.0000
 .6461  .2924  .3124  .2796 0  .2583  .4774 1.0000
 .5460  .3625  .4008  .2387 0  .1755  .3199  .5432 1.0000
-.1250 -.0624  .0206  .0748 0  .1918 -.0304 -.0646 -.1480 1.0000
-.2255 -.0915 -.0095  .0528 0 -.4437 -.4912 -.1419 -.0921 -.1387 1.0000
```

Group 12, Size 3, all brothers

```
M1ED M2ED M3ED nonED1 nonED2 INCOME FOCC FED MED CATH FAFAM
1.0000
 .2999 1.0000
 .3924  .4022 1.0000
0      0      0      1
0      0      0      0  1
 .1515  .1964  .2707  0  0  1.0000
 .3160  .2861  .2167  0  0   .4272 1.0000
 .2766  .2150  .2286  0  0   .2358  .5039 1.0000
 .1591  .1751  .2457  0  0   .1361  .3443  .4752 1.0000
 .0260 -.0777  .0060  0  0   .0184  .1268 -.1223 -.0690 1.0000
-.0923 -.1103 -.0685  0  0  -.3152 -.4514 -.0967 -.1143 -.1716 1.0000
```

Group 13, Size 3, one sister

F1ED	M1ED	M2ED	nonED1	nonED2	INCOME	FOCC	FED	MED	CATH	FAFAM
1.0000										
.4769	1.0000									
.3524	.4041	1.0000								
0	0	0	1							
0	0	0	0	1						
.3308	.3419	.2832	0	0	1.0000					
.3499	.3813	.3540	0	0	.5472	1.0000				
.3601	.4294	.3292	0	0	.4381	.5626	1.0000			
.3259	.3247	.3083	0	0	.3003	.3745	.4770	1.0000		
-.0889	-.0788	-.0458	0	0	.0293	-.0087	-.0821	-.1039	1.0000	
-.1043	-.1177	-.2276	0	0	-.3467	-.4400	-.2223	-.1053	-.0972	1.0000

Group 14, Size 3, two sisters

F1ED	F2ED	M1ED	nonED1	nonED2	INCOME	FOCC	FED	MED	CATH	FAFAM
1.0000										
.5069	1.0000									
.3545	.3390	1.0000								
0	0	0	1							
0	0	0	0	1						
.2543	.2945	.2905	0	0	1.0000					
.3243	.2789	.3130	0	0	.5214	1.0000				
.3856	.3416	.3261	0	0	.4061	.5367	1.0000			
.2972	.2961	.3086	0	0	.3052	.3634	.4678	1.0000		
-.0979	-.0531	-.0466	0	0	.0026	.0036	-.0636	-.1110	1.0000	
-.0844	-.0640	-.1593	0	0	-.3571	-.4444	-.2293	-.0788	-.0846	1.0000

Group 15, Size 3, three sisters

F1ED	F2ED	F3ED	nonED1	nonED2	INCOME	FOCC	FED	MED	CATH	FAFAM
1.0000										
.5118	1.0000									
.4002	.3992	1.0000								
0	0	0	1							
0	0	0	0	1						
.2144	.2049	.1153	0	0	1.0000					
.2887	.3820	.1131	0	0	.4584	1.0000				
.4044	.3715	.1455	0	0	.2924	.5179	1.0000			
.4007	.3802	.3162	0	0	.2458	.2609	.5156	1.0000		
-.0832	-.1216	-.0733	0	0	.1325	.0938	.0188	-.1685	1.0000	
-.0188	-.1175	.0543	0	0	-.3628	-.4565	-.2092	-.0097	-.1675	1.0000

Group 16, Size 2, all brothers

M1ED	M2ED	nonED1	nonED2	nonED3	INCOME	FOCC	FED	MED	CATH	FAFAM
1.0000										
.4549	1.0000									
0	0	1								
0	0	0	1							
0	0	0	0	1						
.3019	.2951	0	0	0	1.0000					
.2872	.3377	0	0	0	.5049	1.0000				
.3695	.3009	0	0	0	.3614	.4813	1.0000			
.3286	.2859	0	0	0	.3270	.3098	.5446	1.0000		
.0044	.0286	0	0	0	-.0102	-.0138	-.1121	-.1061	1.0000	
-.0819	-.2164	0	0	0	-.3077	-.4201	-.2192	-.0967	-.0793	1.0000

Group 17, Size 2, one sister

F1ED	M1ED	nonED1	nonED2	nonED3	INCOME	FOCC	FED	MED	CATH	FAFAM
1.0000										
.4276	1.0000									
0	0	1								
0	0	0	1							
0	0	0	0	1						
.3105	.3399	0	0	0	1.0000					
.3639	.3721	0	0	0	.4986	1.0000				
.3641	.3516	0	0	0	.3350	.5376	1.0000			
.3083	.3138	0	0	0	.2943	.3821	.5171	1.0000		
-.1159	-.0765	0	0	0	-.0181	-.0774	-.1898	-.1993	1.0000	
-.1369	-.2241	0	0	0	-.3775	-.4320	-.2189	-.1531	-.0830	1.0000

Group 18, Size 2, two sisters

F1ED	F2ED	nonED1	nonED2	nonED3	INCOME	FOCC	FED	MED	CATH	FAFAM
1.0000										
.4918	1.0000									
0	0	1								
0	0	0	1							
0	0	0	0	1						
.2314	.2886	0	0	0	1.0000					
.3029	.3121	0	0	0	.4817	1.0000				
.3041	.2949	0	0	0	.3008	.4975	1.0000			
.3463	.2814	0	0	0	.3193	.3738	.4889	1.0000		
-.0983	-.1689	0	0	0	-.1064	-.1970	-.1811	-.2123	1.0000	
-.0632	-.0941	0	0	0	-.3185	-.4024	-.1779	-.1543	-.0400	1.0000

Appendix B. Analyses of Sibship Size Two

In the earlier study (Kuo and Hauser 1993), we did not analyze sibship size two because it requires at least three outcome variables to identify a two-factor model of sibling resemblance. The two-factor model was rejected in our analyses of sibships of sizes three to five. In the current study, to study the relationship between sibship size and the effect of family background on educational outcomes, we add the sample of sibship size two to the analyses. Before pooling all sibship sizes together, we first analyze the sample of sibship size two as we did the other sizes in order to establish a baseline model for integration of samples of the four sizes. To identify the two-factor model or the factor model of Kuo and Hauser (1993), there must be at least three educational outcomes; thus, in this appendix, we only study the structural model, which can be identified with two educational outcomes. The sample of size two is divided into three groups by gender composition: all-brother, brother-sister and all-sister. The first set of hypotheses are related to within-group constraints on parameters such as effects of the common family factor on educational attainments of siblings and the within-family variance of educational attainment; The second set of hypotheses are related to between-group constraints on the preceding parameters and others such as unmeasured between-family variance and the effects of the family background variables on the common factor; The third set of hypotheses are related to means of observable and latent variables.

We report the fit of several alternative models in table B.1. The baseline model is the least constrained model: we only impose a normalizing constraint on the loadings of education on the common family factor. The model fits the data well: $\chi^2 = 29.13$ with 15 *df* and *bic* = -66.26. In model 1, we test the hypothesis that within each gender composition, the effect of the common family factor on the educational attainment of siblings only varies by sex; that is, we impose the equality constraints on λ^y for the all-brother and all-sister groups. The model fits the data better than the baseline model does: χ^2 increases by 0.55 with the increase of two *df*. We fail to reject the null hypothesis. Next, in model 2, we test a null within-group hypothesis on the within-family variance of educational attainment of siblings; that is, we impose the equality constraints on θ^ϵ for the all-brother and all-sister groups. Contrasted to model 1, χ^2 in model 2 increases by 0.22 with an increase of two *df*. Again, we fail to reject the null hypothesis. Thus, we find that, within each gender composition, the within-family variance and the effect of the family factor on the schooling of siblings do not differ by birth order, but they do differ by gender.

From model 3 to model 6, we examine hypotheses about gender composition; that is, technically, we impose cross-group constraints on various parameters. First, in model 3, we impose equality constraints on the effects of family factor on educational attainment of siblings across groups that differ in gender composition: that is, $\lambda^y_{111} = \lambda^y_{121} = \lambda^y_{221} = 1$ and $\lambda^y_{211} = \lambda^y_{311} = \lambda^y_{321}$. This model is statistically equivalent to model 2.[1] Thus, the fit of model 3 is identical to that of model 2. This model does not really constrain the effect of the family factor on educational attainment across groups unless we also impose constraints on the effects of exogenous variables on the common family factor. Next, in model 4, we test the null hypothesis that gender composition does not affect the within-family variance. That is, we impose cross-group constraints on θ_ε for sisters and for brothers. The model fits the data satisfactorily; with an increase of two *df*, χ^2 increases by 3.45. In model 5, we hypothesize that the unmeasured between family variance (Ψ) does not vary by gender composition. It also fits the data of size two very well; with an increase of 2 *df*, χ^2 increases only by 1.88.

In model 6, we test the hypothesis that the effect of family background on the educational attainment of siblings is invariant to gender composition; we impose a cross-group equality constraint on the Γs. The model implies that effects of family background on educational attainment do not vary by gender composition. With an increase of 12 *df*, χ^2 only increases by 11.51. Again, we fail to reject the null hypothesis. Finally, we equalize the coefficients of father's education and mother's education in model 7. The data also fit this constraint: χ^2 increases by 0.51 with an increase of one *df*. As in Kuo and Hauser (1993), we find that the process of educational attainment does not differ by gender composition or birth order and that the effect of mother's education on schooling of offspring as equally important as that of father's education. Only gender moderates effects of family background on the educational attainments of siblings.

We examine hypothesis about the means of observable and latent variables in model 8 to model 13. (The means are unconstrained in all of the previous models.) Model 8 states that, within each gender composition, the mean of years of schooling is the same among brothers but different from the mean among sisters. That is, we equalize means of educational outcomes for brothers and those for sisters. Contrasted with model 7, χ^2 increases by 0.81 with an increase of two *df*. We cannot reject the null hypothesis: within gender composition, average years of schooling for brothers or for sisters are equal regardless of birth order. In the next model, we

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[1] This would only happen in sibship size two because we have only one mixed-sex group, and the degrees of freedom do not change. Because we do not have any equality constraints on the loadings of the common family factors on family background variables (γs), these loadings are reparameterized for the all-sister group. Thus, the estimates in model 2 are uniformly proportional to those in model 1. In the sample of size three or above, we would not see changes in a fit index such as χ^2, but only changes in the degrees of freedom. Note that, the latter does not imply that the model with the cross-group constraints fits better than the model without the constraints. In Kuo and Hauser (1993), we started model selection from the most constrained model. Thus, when we released cross-group constraints on effects of the common family factor on educational attainment, Γs were not reparameterized, and the fit of the model showed us to what extent the alternative hypothesis worked.

impose a constraint of equal mean schooling among all brothers and among all sisters, regardless of gender composition. The hypothesis states that neither gender nor gender composition affects the mean educational attainments of brothers and of sisters. The fit of the model implies that there is negligible variation in mean schooling by gender composition: In contrast to model 8, χ^2 increases by 1.71 with an increase of two *df*. We further test the null hypothesis that there is no difference in educational attainment between men and women. As in our analyses of sibship size 3, 4 and 5, this null hypothesis is easily rejected in sibships of size 2: Contrasted with model 9, χ^2 increases by 133.96 with the increase of one *df*.

In model 11, we impose equality constraints on means of the exogenous variables across groups. That is, socioeconomic status for WLS families of sibship size 2 do not vary by gender composition of the sibship. Again, the model fits the data well: χ^2 = 68.59 with 52 *df* and *bic* = -265.61. The contrast between model 9 and 11 is χ^2 = 18.81 with the increase of 12 *df*. That is, the distribution of socioeconomic background for sibships of size two does not vary by gender composition. In the final model, we estimate the differences in means of educational outcomes between groups differing in gender composition. We release the conventional constraints on means of the latent variables and estimate the differences between the second and third group and the first group. Contrasted to model 11, the fit statistic of model 13 does not improve: χ^2 decreases by 4.37 with the decrease of 2 *df*. In sibships of size two, we find no evidence that educational attainment of siblings differs by gender composition, above and beyond the difference implied by gender differences in attainment.

Our preferred model for sibships of size two is identical to the preferred models for sibship sizes 3, 4 and 5. That is, gender composition does not influence the effect of family background on educational attainment of siblings; brothers are consistently more affected by socioeconomic origin than sisters are; mother's education influences schooling of offspring as much as father's education does; confined by the common family factor, effects of mother's and father's educations on educational outcomes of sons are larger than on those of daughters. Finally, brothers attain more schooling than sisters regardless of gender composition; the educational attainment of brothers or sisters does not vary across gender composition; and socioeconomic background does not differ significantly by gender composition.

Table B.2 shows the estimates of parameters and means. Comparing these to findings of Kuo and Hauser (1993), estimates of effects of family background on educational attainment of siblings and variances (between and within-families) in the sibships of size two are very similar to those in sibships of size three, four and five, except that the significant positive effects of farm background on education of siblings in samples of size two are much bigger than that in samples of other sizes. Also, the means of family background variables and educational attainment of brothers and sisters from sibships of size two are very different from those for size three and above. This is not surprising because of the inverse relationship between socioeconomic status and fertility in the cohorts covered in the Wisconsin sample.

Table B.1. Goodness of Fit Statistics (Sibship Size = 2, n = 1874)

Model		χ^2	*df*	*bic*	Contrast		*p*
0.	Baseline Model	29.13	15	-66.26			
1.	0 + Λ_y within-group constraints	29.68	17	-77.90	.55	2	.760
2.	1 + θ_ε within-group constraints	29.90	19	-89.86	.22	2	.896
3.	2 + Λ_y cross-group constraints	29.90	19	-89.86	.00	0	
4.	3 + θ_ε cross-group constraints	33.35	21	-99.50	3.45	2	.178
5.	4 + Ψ cross-group constraints	35.23	23	-110.70	1.88	2	.391
6.	5 + Γ cross-group constraints	46.74	35	-177.69	11.51	12	.486
7.	6 + $\gamma_{k,2}=\gamma_{k,3}$ constraint	47.25	36	-183.18	.51	1	.475
Mean Structure Model							
8.	7 + τ^y within-group constraints	48.06	38	-194.55	.81	2	.667
9.	8 + τ^y cross-group constraints	49.78	40	-205.92	2.71	2	.425
10.	9 + $\tau_{sister} = \tau_{brother}$	183.74	41	-78.85	133.96	1	.000
11.	8 + τ^x cross-group constraints	68.59	52	-265.61	18.81	12	.093
12.	11+ $\tau_{k,2} = \tau_{k,3}$	123.89	53	-216.31	55.30	1	.000
13.	11- $\alpha_{k,1}$s cross-group constraints	64.22	50	-256.90	-4.37	-2	.112

Table B.2. Parameter Estimates of Preferred Models								
	Sibship Size 2		*Sibship Size 3*		*Sibship Size 4*		*Sibship Size 5*	
Structural Coefficents								
Effect of the Common Family Factor (Λ_y)								
Sister	.76	(.04)	.84	(.04)	.76	(.80)	.80	(.04)
Brother	1.00		1.00		1.00		1.00	
Exogenous Variables (Γ)								
Income	.11	(.02)	.09	(.02)	.10	(.02)	.11	(.02)
Dad's education	.13	(.01)	.13	(.01)	.13	(.01)	.11	(.01)
Mom's education	.13	(.01)	.13	(.01)	.13	(.01)	.11	(.01)
Dad's SEI	.18	(.03)	.15	(.02)	.15	(.03)	.14	(.03)
Farmer	.11	(.16)	.26	(.12)	.35	(.13)	.29	(.14)
Catholic	-.07	(.10)	-.22	(.08)	.16	(.10)	.09	(.10)
Variances								
Unmsr. Between-Family Variance (ψ)	2.14	(.20)	1.57	(.13)	1.42	(.13)	1.27	(.13)
Within-Family Variances (θ_ϵ)								
Sister	2.47	(.12)	2.35	(.09)	2.54	(.09)	2.24	(.08)
Brother	4.58	(.23)	4.71	(.16)	4.39	(.15)	4.04	(.15)
Means								
Means of Schooling (τ^y)								
Sister	13.44	(.05)	13.20	(.05)	12.93	(.05)	12.72	(.05)
Brother	14.33	(.07)	13.77	(.06)	13.39	(.06)	13.05	(.07)
Means of Exogenous Variables (τ^x)								
Income	6.80	(.08)	6.23	(.08)	5.89	(.09)	5.19	(.10)
Dad's Education	10.40	(.08)	10.14	(.08)	9.56	(.10)	9.15	(.11)
Mom's Education	10.94	(.07)	10.72	(.07)	10.40	(.08)	10.13	(.01)
Dad's SEI	4.03	(.06)	3.72	(.06)	3.35	(.06)	2.97	(.07)
Farmer	0.13	(.01)	.17	(.01)	.20	(.01)	.26	(.02)
Catholic	0.35	(.01)	.38	(.01)	.44	(.01)	.44	(.02)

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