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THE EFFECT OF SIBLING SEX COMPOSITION ON WOMEN'S EDUCATION AND EARNINGS*

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This paper documents the impact of siblings on the education of men and women born in the United States between 1920 and 1965. We examine the effect of the number and sex composition of a boy or girl's siblings on that child's educational attainment. We find that throughout the century women's educational choices have been systematically affected by the sex composition of her siblings, and that men's choices have not. Women raised only with brothers have received on average significantly more education than women raised with any sisters, controlling for household size. Since sibling sex composition affects women's educational attainment and plausibly may be unrelated to other determinants of earnings, it may provide a useful instrument for education in earnings functions for women. Our results suggest that standard estimates significantly underestimate the return to schooling for women.

I. INTRODUCTION

The American Association of University Women's recent report on girls and education carefully documents "the continuing gender gaps in educational achievement and participation" between girls and boys in today's schools [AAUW 1992, p. 22]. Its publication contributes to a growing understanding of the differences in educations received by women and men in the United States. Although the differences are now well documented, less is understood about their determinants. There are potentially many

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forces at work. The AAUW Report focuses on the role of public school systems in perpetuating differences between boys' and girls' educational success and goals. Many economists have argued that women themselves have rationally chosen less rigorous curricula and fewer years of formal education because they expect to split their time between the labor force and child rearing [Mincer and Polachek 1974; Goldin and Polachek 1987]. In this paper we focus on the role of the family in shaping boys' and girls' educational choices. Do families contribute to the gap in education by favoring boys in the allocation of educational resources?

Economic models of household behavior portray children's educational attainment as the result of family decision making, in which the household balances efficiency and equity issues to determine the optimal distribution of educational resources [Becker 1991; Behrman, Pollak, and Taubman 1982]. These models offer many scenarios under which girls are forced to compete with (and often stand in line behind) their brothers for an education. Such an effect has been documented in Taiwan by Parish and Willis [1992], who find that the presence of a brother reduces siblings' education.

Research in sociology suggests socialization at home may be a powerful tool in the shaping of girls' and boys' expectations and goals. Parents, together with teachers, classmates, and the media, may send messages to children describing appropriate behavior and goals.[1] The messages delivered by parents may depend, in turn, upon family structure. For example, sibling sex composition appears to affect parental sex-typing of children's household tasks [Brody and Steelman 1985], a phenomenon with potential spillovers in children's attitudes and goals.

Psychologists suggest that family composition may influence education through the effect children have on each other's development. Research has shown that girls with older brothers tend to have more "masculine" traits [Koch 1955]—perhaps because the example of an older brother encourages a girl to be more assertive and outspoken.

Each of these influences suggests specific relationships between sibling sex composition and educational attainment. This paper documents the impact of siblings on the education of women and men born in the United States between 1920 and 1965. We find that throughout the century a woman's educational choices have been systematically affected by the sex composition of her siblings,

1. Epstein [1988] provides a summary of research in this area.

and that a man's choices have not. Women raised only with brothers have received on average significantly more education than women raised with any sisters, controlling for household size. This result is in direct opposition to those found in the literature on developing countries, from which priors on the results for the United States may have been formed.[2]

After discussing mechanisms through which family structure may influence educational attainment, we turn to results for the United States. We then offer explanations for our findings and suggest how they may be used.

II. Sibling Composition and Educational Attainment

The composition of a household may influence children's educational attainment in several ways. One child may change the opportunity cost of investing in the education of another if parents face borrowing constraints. In addition, the cost of raising children may vary by gender or ability, and for this reason sons and daughters may have different effects on the family budget constraint. Interactions among children, or between parents and children, may vary systematically with the sex composition of the sibship. These interactions may influence many facets of child development, including a child's educational goals.

A. Models of Parental Preferences

Becker [1991] and Behrman, Pollak, and Taubman [1982, 1986] suggest strategies for parental investment in children's education.[3] Their models can yield the result that a child's education depends upon the size and sex composition of his or her sibship, but only under specific assumptions.

This result will not obtain, for example, if parents wish to maximize the sum of their children's incomes and face no borrowing constraints. Educational investments in this case will be made until the marginal return to education for each child is equal to the market rate of interest. Women historically spent less time in the labor force than men and for this reason the return to investment

2. See Behrman [1992] for a survey of gender effects in the intrahousehold allocation of nutrients. Recent work by Thomas [1993] provides a cross-country comparison of the relative effects of adult male and female educations on household resource allocation, with height-for-age of boys and girls in the household used as indicators of intrahousehold resource allocation.

3. Most research on the United States has focused on the household as a decision-making unit. For notable exceptions see McElroy and Horney [1981] and Chiappori [1988] for theoretical work on intrahousehold decision making.

in education may have been lower for daughters than for sons.[4] We might therefore expect a systematic difference in the levels of education obtained by sons and daughters. The level of each child's education, however, should be orthogonal to the size and sex composition of his or her sibship. If the existence of a sibling does not affect the return to education for a given child, it cannot affect the optimal level of education for that child.

A child's education may be affected by the size and composition of his or her sibship if the family faces *borrowing constraints*.[5] Parents who wish to maximize the sum of their children's incomes but are limited in their ability to borrow will stop short of investing until the rate of return to each child's education is equal to the market rate of interest. Children with the highest marginal return to education will receive the most education in this case, just as they did in the case where borrowing constraints did not bind. Children's educations, however, are no longer independent of the size and composition of their sibships. If boys receive a higher return to each level of schooling, we should expect to see not only that boys receive more education, but also that the presence of sons reduces the educational attainment of daughters. A girl with only sisters would receive more education than a girl with brothers in this case.[6]

Sibling composition can influence educational attainment in the absence of borrowing constraints only if parents have an aversion to earnings inequality among their children. Parents with such preferences will offset the higher marginal returns of some children by investing more heavily in children with lower returns to education. In contrast to the predictions above, we would expect in this case that if boys had higher marginal returns to each level of education, then girls would receive more education in the presence of brothers.

4. Even on the face of it, it does not follow that women would receive less education than men. Goldin [1992] notes that college attendance significantly increased the probability that a woman's husband was college educated and "among all women who married college men, those who attended college married men with higher incomes" [p. 19].

5. These assumptions underlie much of the work on developing countries in which researchers look for patterns of discrimination in favor of boys in the allocation of household resources, including nutrients, health care, and education. See, for example, Behrman [1988] and Deaton [1989].

6. This result depends upon the presence of borrowing constraints and not upon the exact shape of the parents' utility functions. This result continues to hold in the presence of borrowing constraints when parents care not only about the level of their children's earnings but also about inequality among their children's earnings, as long as parents have less than a complete aversion to earnings inequality.

B. Budget Constraints

The education of daughters may be influenced by sibling sex composition in a manner unrelated to parental preferences, if sons and daughters have differential effects on the resources available to the household. The "price" of having a daughter may be different than that of having a son, because girls and boys require different inputs or because they have different earnings potentials in their teen years (or during the period in which they contribute to household income). Daughters and sons would then have different effects on the family budget constraint. The prices of education for males and females may also differ if one group is eligible for education subsidies, such as the GI bill. If the overall cost of raising a daughter differed systematically from that of raising a son, completed education of both male and female children may depend upon the *percentage* of female children in the household.

C. Child Development

Research in developmental psychology predicts that family composition will influence a child's educational attainment through its impact on the child's personality, interests, and skills. Research beginning with Koch [1955] and Brim [1958] has documented that girls with older brothers exhibit more "masculine" traits while boys with older sisters exhibit more "feminine" traits. This spillover of sex-roles between opposite sex siblings is found among boys and girls at different stages of development.[7] Predictions from this literature differ from those discussed above. A spillover model predicts that a girl with an older brother will receive more education than a girl with an older sister if educational attainment is a masculine trait.[8] This model carries the additional prediction

7. Bigner [1972] documents this result among preschoolers; Rosenberg and Sutton-Smith [1964] among school-aged children; Lamke, Bell, and Murphy [1980] and Rosenberg and Sutton-Smith [1968], among college students. See Stoneman, Brody, and MacKinnon [1986] for a review of this literature. Although the terms "masculine" and "feminine" are difficult to define, some studies have found consensus among preschool aged children in labeling certain activities "masculine" and others "feminine." See, for example, Paludi, Geschke, Smith, and Strayer [1984].

8. Becker [1991] suggests that education is a masculine trait, claiming "biological deviance" for women who pursue formal education. Claiming that "normal" orientation for girls is toward the household and for boys is toward the market, Becker [p. 40] suggests that "investments in children with normal orientations reinforce their biology, and they become specialized to the usual sexual division of labor. Investments in deviant children, on the other hand, conflict with their biology." From this passage we are reminded of John Stuart Mill's [1824, p. 526] observation that "all [women] who infringe on any of the prerogatives which man thinks proper to reserve to himself are called masculine, and other names intended to convey disapprobation."

that a boy with an older sister will receive less education on average than a boy with an older brother.

A related "reference group" theory suggests that the presence of a second daughter in the household changes the reference group for the first. Parents with only one daughter may measure her achievements on the same scale used to measure their sons' and may provide her with an equal share of the household's educational resources. Sons may have a positive externality on a daughter's education if parents have well-defined goals for sons and, in the absence of sisters, a daughter is forced to compete with sons. When a second daughter enters the household, a daughter's reference group may change. Parents may group the daughters together and apply a different standard for homework, grades, and course loads.

The AAUW Report provides an example of how such a reference group effect might manifest itself in educational outcomes. The report highlights the difference in boys' and girls' average preschool skills and suggests that early education has focused on improving skills that most girls have mastered before attending school, including impulse-control training, small-muscle development, and language enhancement. The AAUW Report states that the same attention is not paid to improving girls' facility with the skills with which boys typically enter school, suggesting that "many activities chosen by young boys, such as large-motor activities and investigatory and experimental activities, are considered 'free play' and are not part of the regular structured curriculum. If young girls are not specifically encouraged to participate in these 'boy' activities, they do not receive a full and balanced set of educational experiences" [AAUW 1992, p. 18]. A girl with a brother in her preschool reference group may have the opportunity to develop skills that receive less attention in the classroom. Two daughters, on the other hand, may be more likely to hone those skills that will be rehearsed again in early education, and may be less apt to master skills traditionally associated with boys.

The above example, when extrapolated to other levels of education, suggests that if sibling sex composition affects a girl's reference group, it may in turn affect her education. Such a reference group model predicts that women's educational attainment will depend upon family composition in a particular way: women with *any* sisters will obtain levels of education that differ systematically from those obtained by women with no sisters.

III. Patterns of Educational Attainment

A. Data Sources

We have two specific data requirements to study the question set out above. Individuals surveyed must be old enough to have completed their educations. These people must also provide information on the number and sex composition of the siblings in the households in which they were raised. Many data sets widely used to study education are inappropriate for our use because they provide information on only current household characteristics.[9] We are able to use data from three sources: the Panel Study of Income Dynamics (PSID), the National Longitudinal Survey of Women (NLSW), and the Current Population Survey (CPS).

Our primary source of data is the 1985 Wave of the PSID, which asks detailed questions of both household heads and wives about their parents' educations, the size of the sibship in which they were raised, and the sex of their siblings.[10] We use indicators for parents' educations and a self-reported poverty measure to control for the socioeconomic status of the family.[11] We break the PSID sample into cohorts of women aged 24 to 44 in 1985; women aged 45 to 65; men aged 24 to 44; and men aged 45 to 65.

Summary statistics for family background variables and completed education are presented in Table I by age cohort. Men and women in the older cohort came from significantly larger families, on average, and report more often that they came from "poor" families. Parents of respondents in the older cohort were less likely to have completed high school or college.

The NLSW provides detailed information on family background and completed education for a sample of women aged 30 to 44 in 1967. This cohort may be of particular interest because these women reached adulthood at a time when sex roles were changing; they returned to work in larger numbers after childbearing than

9. The Census of the United States and almost all rounds of the CPS, for example, provide information on respondents' current households only. The High School and Beyond provides some information on family background, but provides no information on the sex composition of the respondents' siblings.

10. Information on birth spacing is not available in the PSID, but information is provided on whether the respondent is the eldest child in his or her family. Our initial research suggested that the impact of family structure on educational attainment is different for whites and blacks; we limit our analysis here to whites. The Data Appendix discusses variable construction in detail.

11. Direct information on the wealth of the household in which the respondent was raised is unavailable. Implications of these data limitations will be discussed below.

TABLE I
SUMMARY STATISTICS: PSID 1985 AND NLSW 1984[a]
(STANDARD DEVIATIONS IN PARENTHESES)

	PSID: ages 24–44		PSID: ages 45–65		
	Men	Women	Men	Women	NLSW
Years schooling	13.63	13.29	12.35	12.08	11.97
	(2.32)	(2.20)	(3.10)	(2.56)	(2.32)
Any sisters	0.80	0.78	0.81	0.82	0.78
	(0.40)	(0.41)	(0.40)	(0.39)	(0.41)
Percent sisters[b]	0.34	0.63	0.34	0.63	0.63
	(0.23)	(0.23)	(0.22)	(0.22)	(0.22)
Number of sisters	1.65	1.64	1.84	2.00	1.72
	(1.45)	(1.46)	(1.60)	(1.75)	(1.51)
Number of brothers	1.80	1.76	2.04	1.96	1.82
	(1.54)	(1.49)	(1.67)	(1.63)	(1.52)
Number of siblings	3.46	3.40	3.88	3.96	3.54
	(2.31)	(2.23)	(2.64)	(2.77)	(2.34)
High school father[c]	0.30	0.32	0.12	0.16	
	(0.46)	(0.47)	(0.32)	(0.37)	
College father	0.25	0.23	0.09	0.11	
	(0.43)	(0.42)	(0.29)	(0.31)	
Completed educ father					8.75
					(3.52)
High school mother	0.51	0.45	0.26	0.25	
	(0.50)	(0.50)	(0.44)	(0.43)	
College mother	0.18	0.21	0.08	0.08	
	(0.38)	(0.41)	(0.28)	(0.27)	
Completed educ mother					9.32
					(3.01)
Oldest sibling	0.30	0.30	0.29	0.29	
	(0.46)	(0.46)	(0.45)	(0.45)	
Poor household	0.19	0.23	0.50	0.45	
	(0.39)	(0.42)	(0.50)	(0.50)	
Father professional					0.07
					(0.25)
Father laborer					0.07
					(0.25)
Mother worked					0.32
					(0.46)
Age in 1985	33.16	33.22	55.45	55.08	54.96
	(5.69)	(5.71)	(5.74)	(5.81)	(4.34)
Observations	1167	1267	660	758	1724

a. Sample restricted to whites. All means weighted using sample weights. PSID: respondents must report completed schooling greater than zero and number of siblings between 1 and 14 inclusive. NLSW: information collected for only first ten siblings, and sample restricted to respondents with siblings between 1 and 10 inclusive who report gender information about siblings. For observations with parent's education missing, mean education for whites assigned.

b. Percent sisters in sibship including respondent.

c. High school father = 1 if father holds a high school degree but no college degree; = 0 otherwise. College father = 1 if father holds a college degree; = 0 otherwise. Mother's education variables are analogously defined.

did women in earlier cohorts.[12] Women in this cohort are the same age, on average, as women in the older cohort of the PSID, although their ages are less dispersed. Women in our NLSW sample are from smaller sibships[13] and, for this reason, are slightly less likely to have any sisters. Mothers of respondents in the NLSW obtained significantly more education on average than fathers, 9.32 years versus 8.75 years. This is consistent with differences in parental education reported by the older cohorts of the PSID, where mothers are more likely than fathers to have at least a high school degree, and with the results of Goldin [1992, p. 5].

The November 1989 CPS Language, Immigration, and Emigration Supplement allows us to compare the average educational attainment of men and women by sibship size. The CPS provides information on only the number and sex of respondents' *living* siblings.[14] The difference between the number of living siblings and the siblings with whom the respondents were raised is larger for older respondents. Thus, measurement error in the variables in which we are most interested, the size and sex composition of the sibship in which the person was raised, increases with age. This makes comparisons between cohorts difficult. The CPS also lacks information on other important family background characteristics, such as parents' education and measures of household wealth. For these reasons, the CPS will play only a corroborating role in our analysis.

B. Educational Attainment of Women and Men

The school attainment of men and women in the United States has increased markedly in the last seven decades. Figure I documents this increase by five-year cohorts in the CPS.[15] The average education of women grew from less than eleven years for the cohorts born before 1920 to more than thirteen years for the youngest cohorts. Women's education lagged behind men's by

12. See Goldin [1992, p. 17].
13. The NLSW limits sex information to a respondent's first ten siblings, which contributes to the difference in sibship sizes between the PSID and NLSW.
14. The CPS asks sibling information by category with "four or more brothers" and "four or more sisters" used to represent larger families. Our CPS analysis is limited to respondents with three or fewer siblings, given the importance of size and sex composition of families in this work. See Data Appendix for further details.
15. The growth in educational attainment will be underreported if people with more education are also people who live longer, because those with less education are less likely to be sampled in older cohorts.

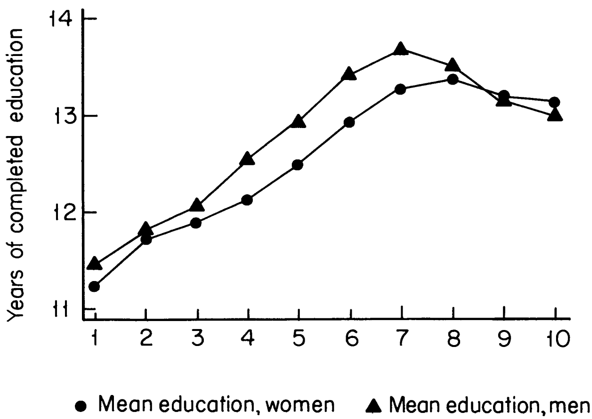

FIGURE I
Cohort 1 = birth year 1916–1920; cohort 2 = 1921–1925.
CPS November 1989, Mean Educational Attainment, Whites

roughly a half year during most of this period, but appears to match men's in the youngest cohorts.[16]

We are also interested in whether sibling composition can help to explain the point at which women lose educational ground. Table II presents points of educational transition by cohort for white women and men in the PSID. The data show that women in the older cohort had a 9 percent higher high school completion rate than men (.72 versus .63 for women and men, respectively). In the younger cohort high school completion rates rose for both sexes, but more for men. Younger women are only slightly more likely than men to complete high school (.86 versus .83 for women and men, respectively). The transition to college represents the point at which a gap has traditionally developed between men's and women's educations. In the older cohort, 44 percent of the women and 58 percent of the men who were graduated from high school attended college. This can be contrasted with 60 percent of women and 70 percent of men in the younger cohort. Women have also increased their college completion rates relative to those of men (.49 versus .57 for women and men in the older cohort; .55 versus .59 for women and men in the younger cohort).

16. This is due in part to the fact that more men than women are enrolled in school through their midtwenties. In the November 1989 CPS the percentage of white men and women aged 24 who listed "going to school" as their primary activity last week were 9 percent and 6 percent, respectively. It is too early to tell what the final educational attainment will be in the youngest cohorts.

TABLE II
FRACTION OF WOMEN AND MEN AT EACH LEVEL OF EDUCATION CONDITIONAL ON COMPLETING THE PREVIOUS LEVEL BY AGE COHORT

	PSID 1985			
Level of education	White women 45–65	White men 45–65	White women 24–44	White men 24–44
Finish high school	.721	.632	.856	.828
(standard deviation)	(.449)	(.483)	(.351)	(.378)
Number of observations	760	662	1267	1167
Start college	.437	.583	.602	.699
	(.496)	(.494)	(.490)	(.459)
	528	406	1058	943
Finish college	.493	.574	.552	.589
	(.501)	(.495)	(.498)	(.492)
	231	261	651	685

For both men and women there has been throughout the century an inverse relationship between sibship size and educational attainment [Blake 1989; Duncan 1974], often attributed to a reduction in the availability of family resources per child. We find in the CPS (see Figure II) that mean education increases from one-child families to two-child families but decreases thereafter. The relationship between number of siblings and educational attainment is robust across men and women. Although the average education of women and men increases as one moves from the oldest to the youngest cohorts, the pattern between number of siblings and education remains firm across age cohorts.[17]

The number of siblings in a family is highly correlated with other measures of family background that affect educational attainment. We run regressions of completed education on number of siblings, parents' education, socioeconomic status, birth order, and religion (see Table III) to understand each variable's independent effect. An additional sibling is associated with a reduction in education of roughly a fifth of a year for both younger and older women, evaluated at mean family sizes. The effect for men has changed significantly over time: an additional sibling reduces educational attainment of older men by roughly a half year and younger men by a third of a year. If sibship size were the only variable that changed through time, the levels of both men's and

17. Similar results are found in the PSID and the NLSW.

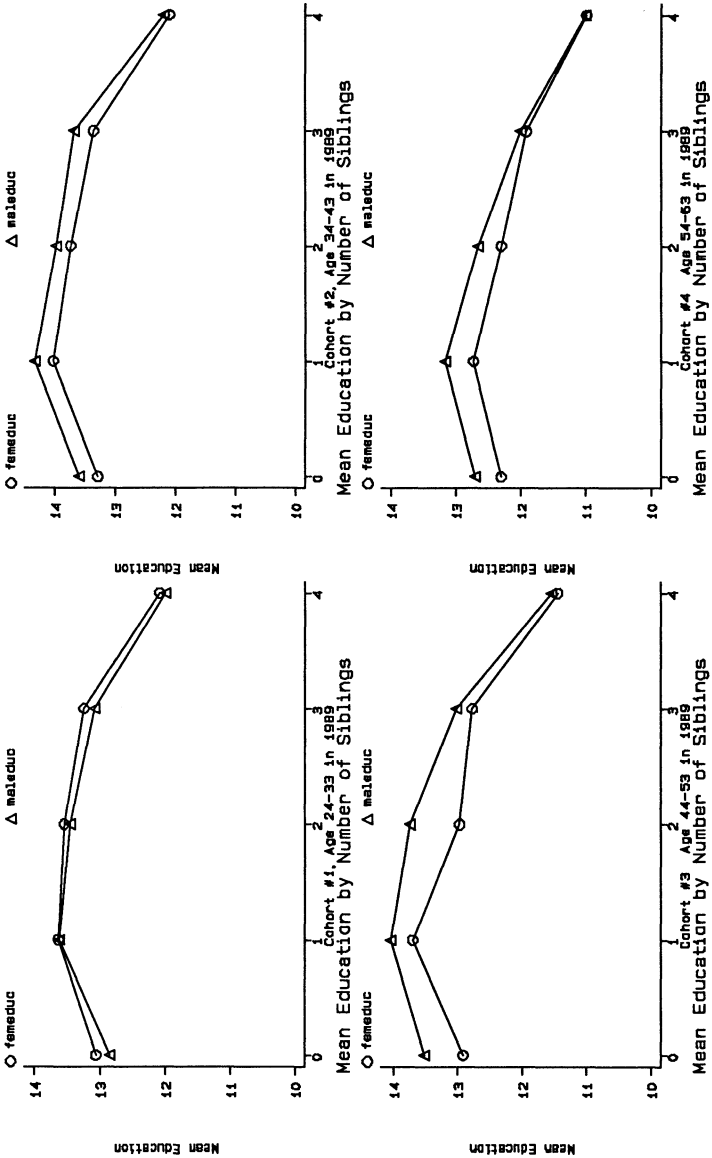

FIGURE II
November 1989 CPS. Educational Attainment for Ten-year Cohorts

TABLE III
YEARS OF COMPLETED SCHOOLING: PSID 1985 AND NLSW 1984[a]
(STANDARD ERRORS IN PARENTHESES)

	PSID: ages 24–44		PSID: ages 45–65		
	Men	Women	Men	Women	NLSW
Number of siblings	−0.342	−0.280	−0.771	−0.230	−0.128
	(0.084)	(0.082)	(0.150)	(0.099)	(0.084)
Number of siblings^2	0.016	0.017	0.045	0.004	−0.008
	(0.008)	(0.008)	(0.013)	(0.008)	(0.009)
High school father[b]	0.619	0.410	0.325	0.729	
	(0.156)	(0.152)	(0.346)	(0.257)	
College father	1.580	1.325	1.102	1.371	
	(0.170)	(0.187)	(0.376)	(0.316)	
Completed educ father					0.109
					(0.019)
High school mother	1.011	0.726	1.268	0.752	
	(0.157)	(0.146)	(0.260)	(0.248)	
College mother	1.629	1.401	1.867	1.902	
	(0.193)	(0.203)	(0.369)	(0.360)	
Completed educ mother					0.188
					(0.022)
Oldest sibling	−0.014	0.136	−0.687	0.246	
	(0.138)	(0.132)	(0.248)	(0.195)	
Poor household	−0.015	−0.493	−0.522	−0.384	
	(0.169)	(0.146)	(0.225)	(0.183)	
Father professional					0.822
					(0.195)
Father laborer					−0.501
					(0.192)
Mother worked					−0.214
					(0.105)
Catholic	0.359	0.235	0.287	−0.061	
	(0.143)	(0.125)	(0.242)	(0.194)	
Age	−2.707	1.250	4.718	−0.526	−0.020
	(1.177)	(1.131)	(5.773)	(4.263)	(0.011)
Age^2	0.092	−0.032	−0.087	0.014	
	(0.036)	(0.034)	(0.105)	(0.078)	
Age^3 ($\times 100$)	−0.099	0.027	0.052	−0.011	
	(0.036)	(0.034)	(0.064)	(0.048)	
F-test: sibsize[c]	4.16	2.92			
(p-value)	(0.016)	(0.054)			
F-test: parents' ed	0.47	0.93			
(p-value)	(0.759)	(0.445)			
Observations	1160	1254	656	756	1724

a. Sample restricted to whites. All regressions weighted using sample weights. Huber standard errors. PSID: respondents must report completed schooling greater than zero and number of siblings between 1 and 14 inclusive. NLSW: information collected for only first ten siblings, and sample restricted to respondents with siblings between 1 and 10 inclusive who report gender information about siblings. For NLSW observations with parent's education missing, mean education for whites assigned and indicator variables included for "mother's education missing" and "father's education missing."

b. Father high school = 1 if father completed high school but not college; = 0 otherwise. Other parents' education variables are analogously defined.

c. F-test: sibsize is a test of joint significance of the differences between coefficients in younger and older cohort regressions on Numsib and Numsib.^{2} F-test: Parents' ed is an analogous test for the four parents' education variables.

women's educations would be expected to rise. The gap between them, however, would be expected to grow, as the negative effect of siblings on men's education is smaller for the younger cohort.

Parents' educational attainment positively and significantly influences schooling for both men and women. The effect of mother's education is larger than that of father's, which may reflect that mothers have a greater influence on children or that mother's education is in part proxying for the wealth of the household. Parents' educations have increased over time (see Table I), which leads us to expect an increase in the levels of children's educations. The effects of parents' educations are not significantly different for men and women within or between cohorts. (*F*-tests for between-cohort differences are provided at the bottom of Table III.)

The results show that family background variables are important determinants of schooling. We will continue to control for these characteristics in the regressions that follow.

IV. THE IMPACT OF SIBLING SEX COMPOSITION ON EDUCATIONAL ATTAINMENT

The sex composition of siblings has a significant effect on the educational attainment of girls. Table IV presents the mean completed years of schooling by number of siblings for the PSID, the NLSW, and the CPS. Sibling sex composition should be orthogonal to personal and family background characteristics; therefore, differences in these means reveal that sibling sex composition matters. In two-children families, a woman with a brother receives significantly more education than a woman with a sister, in all three data sets. The difference is roughly a half year more education (13.9 versus 13.4) in the PSID. In the NLSW it is a third of a year (12.8 versus 12.4), and in the CPS it is significant although smaller (13.7 versus 13.5).

Men from two-children families show no significant difference in educational attainment based on sibling sex composition. The mean education of men with a brother compared with men with a sister is virtually identical (13.99 versus 13.96) in the PSID. In the CPS, although men with a sister appear to receive more education on average than men with a brother, the difference is insignificant (13.82 versus 13.88, *t*-statistic = 0.85).

If parents prefer a "gender mix"—that is, if parents prefer to have children of both sexes in their households—those with all girls or all boys would desire an additional child if they could afford

TABLE IV
MEAN YEARS OF COMPLETE EDUCATION FOR WOMEN AND MEN BY NUMBER AND SEX OF SIBLINGS
(STANDARD ERRORS IN PARENTHESES)

Number and sex composition of siblings[a]		PSID[b] Women	PSID[b] Obs	PSID[b] Men	PSID[b] Obs	CPS[c] Women	CPS[c] Obs	CPS[c] Men	CPS[c] Obs	NLSW[d] Women	NLSW[d] Obs
0 siblings		13.42	105	14.26	104	12.89	3946	13.19	3606	12.63	176
		(0.25)		(0.23)		(0.05)		(0.05)		(0.19)	
1 sibling	0 sisters	13.90	184	13.99	168	13.68	3232	13.82	3004	12.75	215
		(0.17)		(0.21)		(0.04)		(0.05)		(0.14)	
	1 sister	13.39	178	13.96	143	13.54	2920	13.88	3116	12.40	188
		(0.18)		(0.19)		(0.05)		(0.05)		(0.18)	
2 siblings	0 sisters	13.46	126	14.58	103	13.38	1688	13.64	1532	12.50	132
		(0.21)		(0.20)		(0.06)		(0.07)		(0.22)	
	1 sister	13.30	205	13.95	212	13.29	3740	13.57	3582	12.52	208
		(0.16)		(0.16)		(0.04)		(0.05)		(0.14)	
	2 sisters	13.34	83	13.95	97	13.26	1676	13.48	1640	12.11	101
		(0.25)		(0.22)		(0.06)		(0.07)		(0.21)	
3 siblings	0 sisters	13.73	47	13.04	53	13.03	674	13.10	682	11.93	39
		(0.36)		(0.28)		(0.10)		(0.12)		(0.37)	
	1 sister	12.92	153	13.76	146	13.00	2155	13.12	2010	11.75	110
		(0.20)		(0.22)		(0.05)		(0.06)		(0.20)	
	2 sisters	12.71	159	12.86	108	12.97	2071	13.11	1963	12.15	117
		(0.18)		(0.26)		(0.05)		(0.07)		(0.21)	
	3 sisters	12.92	52	13.11	45	13.17	724	13.09	598	12.31	33
		(0.29)		(0.37)		(0.09)		(0.11)		(0.29)	

a. PSID and NLSW weighted using sampling weights.
b. PSID restricted to whites, greater than age 23 and less than age 66, reporting a positive amount of completed schooling.
c. CPS restricted to whites, greater than age 23 and less than age 64. CPS reports only on living siblings.
d. NLSW restricted to white women who report gender information about their siblings.

one. We might then expect two-children (girl, girl) and (boy, boy) families to be poorer on average than two-children (girl, boy) families. If resources permitted, the single-sex households would have had an additional child. Table IV shows that the difference in average education received by women with a sister relative to women with a brother is significant, although the difference in average education received by a man with a brother relative to a man with a sister is not. If the absence of a gender mix meant that all single-sex families were poorer on average, both men's and women's educations should be affected in a similar fashion.[18] The results in Table IV suggest that this is not the explanation for the differences.

The relationship between sibling composition and the education of daughters is also apparent in larger families. In the PSID, in three-, four-, and five-children families, women with no sisters receive more education on average than women with any sisters.[19] This difference is significant for women with three siblings (13.7 versus 12.8, t-statistic = 2.4) and for women with four siblings (13.5 versus 12.6, t-statistic = 1.8). In the CPS in three-children families women with no sisters receive more education on average than women with any sisters. However, this difference is not significant (13.38 versus 13.28, t-statistic = 1.44).

The results in Table IV suggest that, within sibling groups of the same size in the PSID, the drop in women's average schooling occurs as one moves from households in which women have no sisters to households in which women have one sister. Additional sisters, given sibship size, do not reduce educational attainment further. This pattern is also suggested in the two-sibling case of the CPS. Table IV suggests why an "any sisters" indicator may have more explanatory power than will a "percentage female" variable.

No clear relationship emerges between educational attainment and the sex composition of siblings for men from larger families, either in the PSID or the CPS. In three-children families in the PSID, men without sisters receive significantly more education than men with any sisters (14.6 versus 14.0). However, as was true for two-children families, in families with four or five children the educational attainment of men appears to be orthogonal to sibling sex composition, with the mean education of men with

18. None of our data sets contains a direct measure of income or wealth for the household in which the respondent was raised.

19. The mean education of women with any sisters, in three-child families, is the average for women with one or two sisters, weighted using sampling weights. Note that the results for five-child families are not reported in Table IV. They are available upon request.

sisters insignificantly different from the mean education of men without sisters. The results for men are also without a discernible pattern in the CPS.

The results in Table IV suggest that women's schooling is influenced by both family size and the sex composition of siblings. Men's schooling, however, is unaffected by the sex composition of siblings. We next turn to regression analysis to test the path through which such an effect takes place.

A. Specifications

The models discussed in Section II suggest different mechanisms through which family composition may influence educational attainment. We begin by presenting the results of two specifications. If the introduction of a sister changes a daughter's reference group within a household, an indicator variable for the presence of any sisters should be significant in regressions of completed education. If, instead, borrowing constraints caused women's educational decisions to depend on the overall sex composition of their siblings, or if girls and boys have different effects on a family's budget constraint, educational attainment should depend on the percentage of children within the household (including the respondent) who are female. The results of adding each of these controls to schooling regressions are provided in Table V. We restrict our attention to the PSID and the NLSW to control for the family background variables discussed in Section III.

Consistent with the results presented in Table IV, the educational attainment of men does not appear to depend on sibling composition. The coefficients on both family variables, "any sisters" and "percentage female," are small and insignificant. This result also holds when schooling regressions are run separately by age cohort. One might believe that the impact of having a sister is smaller in larger families. Men's education, however, continues to be orthogonal to sibling composition when we allow for both an indicator for any sisters and an interaction term between any sisters and number of siblings.[20]

20. For men in older age cohorts, completed education appears to be negatively related to the presence of any sisters if one does not control adequately for the number of siblings in the family. The probability of having a sister increases with the number of siblings. In the older male age cohorts, if one does not allow for nonlinearity in the effect of number of siblings, this effect is picked up by the "any sister" indicator variable. However, this indicator variable becomes insignificant either when one adds a squared term in number of siblings, as is done in Table V, or if one adds indicator variables for each sibship size. The results for women, presented below, are robust to controlling for family size using indicator variables.

TABLE V
SIBLING SEX COMPOSITION AND EDUCATIONAL ATTAINMENT
(STANDARD ERRORS IN PARENTHESES)

Explanatory variables:	PSID[a]								NLSW[b]			
	Men				Women				Women			
Indicator variable, any sisters	0.052 (0.146)	—	—	0.244 (0.224)	−0.302 (0.134)	—	—	−0.278 (0.195)	−0.246 (0.118)	—	—	−0.381 (0.190)
Indicator variable, any brothers	—	0.094 (0.155)	—	—	—	0.227 (0.134)	—	—	—	0.250 (0.134)	—	—
Percentage of siblings female (including respondent)	—	—	−0.123 (0.251)	−0.433 (0.387)	—	—	−0.399 (0.220)	−0.057 (0.319)	—	—	−0.195 (0.210)	0.299 (0.335)
Number of siblings	−0.507 (0.079)	−0.513 (0.082)	−0.491 (0.078)	−0.515 (0.079)	−0.186 (0.067)	−0.272 (0.066)	−0.258 (0.063)	−0.194 (0.076)	−0.078 (0.090)	−0.180 (0.086)	−0.142 (0.085)	−0.029 (0.105)
Number of siblings^2	0.027 (0.007)	0.028 (0.007)	0.026 (0.007)	0.028 (0.007)	0.006 (0.006)	0.011 (0.006)	0.010 (0.006)	0.006 (0.006)	−0.012 (0.010)	−0.004 (0.009)	−0.007 (0.009)	−0.015 (0.010)
Number of observations	1816	1816	1816	1816	2010	2010	2010	2010	1724	1724	1724	1724
R^2	0.2989	0.2990	0.2990	0.2994	0.2880	0.2870	0.2872	0.2880	0.3198	0.3197	0.3187	0.3202

a. PSID regression includes indicators for poor household, oldest child, parents' high school and college degrees, age, age^2, age^3, catholic indicator, and an intercept. Sample restricted to respondents with $0 <$ number of siblings < 15. Sample restricted to white respondents aged 24 to 65 reporting a positive amount of education. Mother HS degree = 1 if mother completed high school but not college; = 0 otherwise. (Other variables of parents' education are analogously defined.) Mean completed education for women in the PSID is 12.84 years (std. dev. = 2.41). Mean completed schooling for men in the PSID is 13.18 years, (std. dev. = 2.70).

b. NLSW women are aged 48 to 62 in 1985, the year for which the PSID data are available. Regression includes age, mother's and father's years of education and indicators for father professional, father laborer, and mother working. For observations with mother's or father's education missing, mean education assigned and indicator variables included for "mother's education missing" and "father's education missing." Mean education for NLSW is 11.97 years (std. dev. = 2.32).

The presence of any sisters has a significant impact on women's education. The PSID and the NLSW provide a consistent picture of this effect. The addition of a sister reduces a woman's education by 0.30 years in the PSID and by 0.25 years in the NLSW, holding family size and background constant. It appears that the influence is working through the presence of any sisters, and not through the percentage of all siblings who are female. In the PSID the "percentage female" variable is marginally significant when added by itself. Particularly for women from small families, the "any sister" variable and the "percentage female" indicator are highly correlated. In the absence of the "any sister" indicator, the "percentage female" variable may be picking up its effect. We add both variables to the regression, to test their relative effects. Neither is significant, due to multicollinearity. The "any sisters" coefficient, however, is large (-0.28) with a t-statistic of roughly 1.5. The "percentage female" coefficient is small (-0.06) with a t-statistic of roughly 0.2. We removed two-children families from the sample and re-estimated the education regressions in order to reduce the multicollinearity. We find that the "any sisters" variable, entered alone, is marginally significant (t-statistic = 1.64), but the "percentage female" variable, entered alone, is not (t-statistic = 1.26).

In the NLSW the "percentage female" variable is insignificant, whether added to the education regression alone or together with the "any sisters" indicator. The coefficient on "any sisters," in contrast, is negative and significant, regardless of the presence of the "percentage female" variable.

The regression results of Table V, taken together with the results from Table IV, suggest that sisters negatively impact each other's educational attainment.[21]

B. Educational Transitions and the Changing Impact of Sibling Sex Composition

We now use an indicator for the presence of any sisters to analyze the impact of sibling sex composition on educational transitions and to explore whether changes in the impact of sibling composition over time can help to explain the changes in educational transitions reported in Table II. We run regressions at three points of transition: completing high school, attending college upon

21. Additional specification tests revealed the same pattern. For both the PSID and the NLSW, an interaction term between the "any sisters" indicator and number of siblings variable was insignificant.

high school completion, and earning a college degree upon college attendance. The first set of columns in Table VI refers to the older cohort (ages 45 to 65 in 1985), and the second set refers to the younger cohort (ages 24 to 44 in 1985). Men's educational attainment appears to be orthogonal to sibling sex composition, and for this reason, we focus only on women.

It is apparent that there are differences in the effect of sibling composition between cohorts. Sisters significantly reduce the probability that the respondent finishes high school, by 9 percent on average, for the older cohort. Sisters have an additional effect in this cohort: conditional on college attendance, the presence of a sister reduces the probability that women finish college by roughly 13 percent. For the younger cohort the situation has changed. Sisters no longer influence the probability of high school graduation, but continue to exert a negative effect on the probability that women finish college. The effect of sisters on college completion rates is smaller (.08) and less significant in the younger cohort. In neither cohort does the effect of having a sister appear to significantly affect the probability that a woman goes on to college conditional on completing high school.

TABLE VI
EDUCATIONAL TRANSITIONS FOR WOMEN, PSID 1985[a]
(STANDARD ERRORS IN PARENTHESES)

	Older women (45–65 years old)			Younger women (24–44 years old)		
Explanatory variables:	HS degree[b]	Attend college	College degree	HS degree	Attend college	College degree
Indicator variable, any sisters	−0.093 (0.042)	−0.048 (0.056)	−0.132 (0.079)	−0.001 (0.022)	−0.028 (0.037)	−0.080 (0.050)
Number of siblings	−0.011 (0.022)	−0.028 (0.029)	−0.059 (0.051)	−0.007 (0.016)	−0.041 (0.023)	−0.040 (0.030)
Number of siblings^2	−0.001 (0.002)	0.003 (0.003)	0.002 (0.005)	−0.001 (0.002)	0.003 (0.002)	0.003 (0.003)
Number of observations	762	528	231	1267	1058	651
R^2	0.1444	0.1503	0.1541	0.1596	0.1505	0.0740

a. PSID regression includes indicators for poor household, oldest child, parents' high school and college degrees, age, age^2, age^3, and an intercept. Sample restricted to respondents with $0 <$ number of siblings < 15. Sample restricted to white respondents aged 24 to 65 reporting a positive amount of education. Mother HS degree = 1 if mother completed high school but not college; = 0 otherwise. (Other variables of parents' education are analogously defined.)

b. Dependent variables: HS degree = earned high school degree; Attend college = attended college, conditional on HS degree = 1; College degree = earned college degree, conditional on attend college = 1.

Results in Table VI suggest that the impact of sibling sex composition has changed between the cohort born 1920 to 1940 and that born 1941 to 1961, with the negative effect of having a sister declining for the younger cohort. This suggests that a change has occurred in the way households allocate educational resources.

C. Discussion

It is difficult to reconcile our results with the economic models of family decision making presented in Section II. If parents wished to maximize the sum of their children's incomes and faced no borrowing constraints, we expect sex composition to be orthogonal to educational attainment for both men and women. This is not consistent with the results presented in Tables IV through VI. Parents who face borrowing constraints might be expected to channel resources to their sons at the expense of their daughters. Instead, we find that, holding family size constant, girls with brothers receive more education than girls with any sisters.

Parents with an aversion to earnings inequality among their children would be expected to provide more education to children with lower returns to education. If the return to education were lower for women, girls with brothers would receive a disproportionate share of the family's education resources. An additional implication, however, is that boys with any sisters would receive less education than boys with only brothers. We find no evidence of this in our data.

We may have expected sibling composition to affect educational attainment through its effect on the family's budget constraint. If this were the case, we would expect both women's and men's schooling to be influenced by the percentage female among siblings in the family. We do not find a symmetric effect. Men's schooling in both cohorts is insensitive to the sex composition of siblings. Women's education responds not to the percentage of siblings that are female but to the presence of any sisters.

It is also difficult to find evidence in favor of developmental psychology models that suggest the importance of cross-sex older siblings. For a subsample of the NLSW, we had information on sibling birth spacing. We used this information to test for potential influence of older cross-sex siblings. We find, in contrast to the results in the developmental psychology literature, no significant effect of having an older brother in a nearby age range.

There are several explanations consistent with the negative and significant effect of "any sisters" in the education regressions presented in Tables V and VI. Family composition may be correlated with parental bias in favor of one sex. If there is a distribution of tastes over sons and daughters, those parents biased in favor of daughters may systematically stop having children after they have a girl but continue to have children if they have a boy. Women without sisters would be more likely to come from families that favored girls, and these women would receive more education. If this were the mechanism at work, we would be more likely to see women who were both only daughters and youngest children receive more education than women who were only daughters and first- or middle-born children. We do not find such an effect in the subsample of respondents for whom we can reconstruct birth order position.[22]

An "any sister" indicator would also be significant if parents favor scarce "commodities"—such as only daughters or only sons. We would expect, then, that boys without brothers would be similarly favored. An "any brother" indicator would be negative and significant in men's schooling regressions just as the "any sister" indicator is in women's schooling regressions. Results in Table V suggest that this is not the case.

Our results are more consistent with a reference group model. In the older cohort the presence of any sisters reduces education for women, perhaps because it changes parents' educational goals for their daughters and thus the family resources allotted to daughters' educations. The change over time observed in the impact of sibling sex composition may reflect change in parental expectations for daughters. It may have become less harmful to a woman's education to be grouped with her sisters.

A reference group model can also explain the observed asymmetry between boys and girls in the effect of family composition on educational attainment, if the presence of a sister works directly to change a young woman's skills. Girls will be more sensitive to sibship composition if, as discussed in Section II, schools compensate for the skills that boys lack when entering school but do not compensate for the skill deficit of girls who do not have brothers in their reference group.

22. There is a widespread belief that birth order matters for educational attainment. We find no such effect, consistent with the results of Hauser and Sewell [1985]. Birth order effects are often confounded empirically with those of sibship size. A person is more likely to be the first-born sibling if he or she comes from a small family. In addition, mothers appear to be significantly more likely to label their first-born child as "gifted," although independent testing of first- and second-born children reveals no significant difference in intelligence based on birth order [Tuttle and Cornell 1993].

D. Other Economic Outcomes

If the presence of a sister changed a woman's educational goals, it may also have an impact on other aspects of her economic life. Table VII presents estimates of the effect of "any sisters" on four outcomes for younger and older women in the PSID. We focus on indicators for whether a woman is currently working, is currently married, has never married, and has any children. These variables might be expected to be linked to both schooling decisions and sibling sex composition.

We find no effect of "any sisters" on these economic outcomes for older women. For younger women we find no effect of any sisters on the probability of being currently married, having ever married, or having any children. However, we do find a marginally

TABLE VII
SIBLING COMPOSITION AND OTHER SOCIOECONOMIC OUTCOMES
WHITE WOMEN PSID 1985[a]

	Socioeconomic outcomes Older women (45–65 years old)			
	Currently working[b]	Currently married	Never married	Any children[c]
Mean of dependent var (standard deviation)	0.505 (0.500)	0.744 (0.437)	0.029 (0.168)	0.907 (0.291)
Explanatory variables:[a]				
Indicator variable, any sisters (standard error)	−0.015 (0.052)	0.029 (0.050)	−0.011 (0.024)	0.004 (0.038)
Number of observations	666	756	756	756
	Socioeconomic outcomes Younger women (24–44 years old)			
Mean of dependent var (standard deviation)	0.685 (0.465)	0.726 (0.446)	0.117 (0.322)	0.774 (0.418)
Explanatory variables:				
Indicator variable, any sisters (standard error)	0.063 (0.039)	−0.008 (0.035)	0.009 (0.026)	0.030 (0.030)
Number of observations	1085	1254	1254	1254

a. PSID regression includes indicators for poor household, catholic, oldest child, parents' high school and college degrees, age, age^2, age^3, number of siblings, number of siblings^2, and an intercept. Sample is restricted to respondents with $0 <$ number of siblings < 15. Parents' degrees are defined as in Table I.

b. Observations are dropped if respondent reported working but reported no earnings on her current job or if the respondent reported not working, but reported earnings on her current job. Respondents reporting earning a dollar an hour or less were also excluded.

c. Regression also includes an indicator that the respondent is married.

significant positive effect of having any sisters on the probability of currently working for the younger cohort. This may be attributable to the impact of "any sisters" on educational attainment. When this regression is run for the youngest women in this cohort, aged 24 to 29, the presence of any sisters increases the probability of working by 14 percent (p-value = 0.055). When run for women aged 30 to 44, there is no significant effect of "any sisters" on the probability a woman is currently working (p-value = 0.474). Women aged 24 to 29 are likely to be either in school or working. If the presence of any sisters reduces the probability that a young woman is currently in school, it may increase the probability that she is currently working.[23]

Sibling sex composition has an effect on women's schooling, but does not appear to have an effect on other relevant economic outcomes. This suggests that sibling sex composition may be useful as an instrument in estimating returns to education.

V. Education and Earnings: Using Sibling Sex Composition as an Instrument

The results above suggest that sibling sex composition may be useful as an instrument in the study of the effects of education on wages. Labor economists have long recognized that part of a worker's wages are attributable to education and part to innate ability. A regression of wages on education will overestimate the return to education if ability is unobserved and is positively correlated with education. The sexes of siblings may be used as instruments in measuring the return to education if they help to determine the amount of education a child receives but are orthogonal to innate ability. Completed education may be reported with error, leading to attenuation bias in estimated returns to education.[24] Sibling sex composition may be used as an instrument to estimate returns to education if it is correlated with educational attainment and uncorrelated with measurement error. Ability bias and measurement error may be thought to have offsetting effects

23. Our results are consistent with those of Kessler [1991] who finds that women from large families are more likely to be working when they are young than are women from small families. We know from our work above that educational attainment falls with increases in sibship size and, even if for no other reason, we would expect to find Kessler's result. For women aged 24 to 29, the effect of "any sisters" on the other outcomes in Table VII is insignificant.

24. See Griliches [1979] for a full discussion.

TABLE VIII
ORDINARY AND TWO-STAGE-LEAST-SQUARES ESTIMATES OF RETURNS TO EDUCATION
WHITE WOMEN, PSID 1985
DEPENDENT VARIABLE: LOG HOURLY EARNINGS[b]
(STANDARD ERRORS IN PARENTHESES)

Explanatory variables:[a]	OLS	Reduced form	TSLS[c] (anysis)	TSLS[d] (anysis, numsib, numsib^2)
Years of education	0.091	—	0.184	0.182
	(0.007)		(0.113)	(0.055)
Any sisters	−0.033	−0.066	—	—
	(0.037)	(0.040)		
Number of siblings	−0.025	−0.039	−0.009	—
	(0.020)	(0.021)	(0.032)	
Number of siblings^2	0.002	0.003	0.001	—
	(0.002)	(0.002)	(0.002)	
Number of observations	1061	1061	1061	1061
R^2	0.2366	0.1168		

a. Also included in the regression: intercept, age, age^2, age^3, indicators for Catholic, oldest child, poor household, and parental education variables Mother HS degree, Mother college degree, Father HS degree, Father college degree. Sample includes white women between the ages of 24 and 65 with a positive number of years of education and at least one sibling, but fewer than 15 siblings. All regressions weighted using sampling weights.

b. The dependent variable is hourly earnings on the worker's "main job." It is hourly wages for those who report being paid hourly, and the salary converted to an hourly figure for those who report receiving an annual salary. People were excluded if they reported working but reported no earnings, or reported no work but did report earnings. People who reported earning a dollar an hour or less were also excluded.

c. Indicator variable for "any sisters" is used as an instrument for years of education.

d. Indicator variable for "any sisters," number of siblings, and number of siblings^2 are used as instruments.

on the noninstrumented estimate of returns to education, and thus it is an empirical matter whether the ordinary least squares estimate in this case is too large or too small.

Table VIII presents the results of log earnings regressions, with and without instrumenting for years of completed education. The dependent variable is log hourly earnings on the respondent's current job, for both hourly wage employees and salaried employees. A full description of this variable is given in the Data Appendix.

The first column presents an estimate of the return to education for women in the PSID from an OLS regression. This estimate of 9 percent is similar to those found by other researchers using U. S. data.[25] An indicator that the respondent had a sister is

25. The results of eight studies reported in Griliches all find returns to education in this range, as does more recent work by Ashenfelter and Krueger [1992] and Card [1993].

insignificant in the log earnings regression when completed education is included as an explanatory variable. The reduced-form estimation, with completed education omitted, suggests that the presence of a sister reduces log hourly earnings by roughly 7 percent (p-value = 0.10), regardless of the underlying explanation for this result.

We present two sets of instrumental variables estimates. In the first we instrument for years of completed education using only the "any sisters" indicator variable. In this estimation the return to education for women doubles to 18 percent. Our results are robust to running the samples of married and single women separately. The estimate for the older cohort run separately is 19 percent, but with only 328 observations this estimate is less precise (p-value = 0.177). The second set of instruments includes an "any sisters" indicator, the respondent's sibship size, and sibship size squared. The IV estimate remains 18 percent in this specification for both the full sample and the older cohort estimated separately, but the estimates are more precise (p-values = 0.001 and = 0.020 for the full sample and older cohort, respectively).

There are at least two explanations for the two-stage-least-squares results presented here. Sibling sex composition may have a direct effect on earnings capacity, through some unobservable effect of siblings on the respondent's productivity later in life. If this were true, an indicator of a sister's presence would *not* be a valid instrument. It would be inappropriate to restrict sibling sex composition from entering the second-stage equation directly in this case. If the presence of any sisters influenced a woman's propensity to work, it may be expected to have an independent effect on a woman's wages. We found no such effect in the 1985 PSID (see Table VII).

A second explanation consistent with our two-stage-least-squares estimates is that attenuation bias significantly reduces ordinary least squares estimates of returns to education. The IV estimates in Table VIII are large relative to those found by researchers who do not instrument for measurement error, but they are very similar to those found in other recent studies. Ashenfelter and Krueger [1992] use data reported by twins to instrument for completed education and estimate an 18 percent return to education. Card [1993] uses geographic proximity to a four-year college to instrument for completed education (NLS

Young Men) and finds that the estimated return to schooling doubles (0.07 to 0.13).[26]

How large would the measurement error have to be to yield these results? If years of completed schooling were the only covariate in the regression and instrumentation resulted in a doubling of its coefficient, this would suggest that measurement error accounted for half the total measured variance in schooling. Upon the addition of other covariates, this need not be the case. If other covariates are correlated with the true component of schooling, they will absorb part of its signal, exacerbating the effect of measurement error.[27] It is difficult, without more information, to comment on the relative sizes of the variance in years of completed schooling and the variance in its measurement error that would be consistent with the findings above, given the number of covariates used in estimation. Through simulation, we can get some sense of whether the increase in the estimated return to education seen here is reasonable. In the simulation we treat completed education in the PSID as free from measurement error and add to it a random component whose variance is a realistic 15 percent[28] of the total variance in reported schooling. For women in the PSID this has the effect of reducing the OLS estimate of the return to education by 30 percent, from 9.1 to 6.7 percent. This is consistent with an example presented in Griliches [1977, p. 12] in which it is demonstrated that the downward bias due to measurement error in estimated return to schooling can be large when covariates correlated with true schooling are added to the regression.

It does not appear, however, that measurement error alone could be responsible for the difference between our OLS and IV estimates of return to schooling. Ability bias may be working in the same direction as the measurement error, forcing the coefficient toward zero. See Card [1993, p. 24] for a discussion of this less conventional view of ability bias.

26. When Card uses geographic proximity to a public college as an instrument, he estimates a return to schooling of 19 percent [Card 1993, Table 4].

27. If education were the only covariate measured with error, return to education would be biased downward by $(1 + \sigma_u^2 X^{ee})$, where σ_u^2 is the variance in measurement error and X^{ee} is that element of the inverse of the limiting variance-covariance matrix of true covariates associated with education. See Levi [1973] for discussion of the size of the bias caused by measurement error in the presence of other covariates.

28. See Griliches [1977] and references therein.

VI. Conclusion

The AAUW findings increased interest in alternatives to the traditional classroom. Citing several recent research studies, the AAUW Report discusses a tendency "beginning at the preschool level for schools to choose classroom activities that will appeal to boys' interests and to select presentation formats in which boys excel or are encouraged more than are girls" [AAUW, p. 71]. Our findings may be complementary to those reported by the AAUW. In the current classroom environment, women raised only with brothers may be in a better position to compete for classroom resources and teachers' attention than are women raised with any sisters. Changes in the structure of classrooms may benefit all girls, with the greatest gain witnessed by girls raised with sisters.

It is clear from the results presented in Section IV that more work is needed to understand why women with sisters have received less education on average than women with brothers. No simple model of household resource allocation explains our findings, and in future work we hope to explore the potentially complex impact of family composition on a family's budget constraint, resource allocation, and time use. In addition, the impact of family structure both on child development and on the quality of education received deserves greater attention.

Our results in Section V suggest that knowledge of family structure may provide a new mechanism with which to instrument for completed schooling. Without correction for measurement error, it appears that one would significantly underestimate the returns to education.

Data Appendix

This Data Appendix describes variables constructed from the Panel Study of Income Dynamics (1985), the Current Population Survey (November 1989), and the National Longitudinal Survey of Women (1984). Programs used are available upon request.

Panel Study of Income Dynamics

The PSID survey of household heads and wives in 1985 combines a representative cross section of families and a subsample of low-income families. We weight our data using the 1985 individual sample weights. In limiting our sample to whites, we eliminate a large fraction of the low-income subsample. The data are organized by household. We extract the relevant variables, described below, and reshape the data so that they are organized by individual. In contrast to earlier waves, the 1985 PSID survey asked questions directly of wives.

Years of Completed Education. We construct a "years of completed education" variable from the series of questions on educational transitions. If the individual has no high school diploma and no GED, then the highest grade completed is 1–11, according to the answer given to the question, "How many grades of school did you finish." If the individual received a high school diploma or a GED, then we check to see if s/he reports having attended college. If not, the number of years of schooling completed is 12. If the individual reports attending college, but did not complete the first year, the number of years of schooling remains 12. If the individual reports attending college, then the number of years of college completed is added to the 12 for high school. Beyond college, the only information given is to the highest degree received: master of arts or science, doctorate, law degree, medical degree. Very few individuals report these advanced degrees, and we limit our completed education variable to 0–17 years.

Family Background. The individuals are asked whether their parents were "poor, average, or pretty well off" (V11921). If the individual responded "poor," we created an indicator variable equal to one for having grown up in a poor household. Similarly, the individuals were asked about their parents' educational attainment (V11922, V11923). This information is given in categorical form, with categories included for high school completion and college degrees. We created indicator variables for each parent's high school degree and each parent's college degree.

Information regarding brothers and sisters is listed separately, but the data are analogous. The individual's responses to a series of questions are listed: "Did you have any sisters?" If yes, "How many sisters was that?" These questions are meant to refer to the total number of brothers and sisters the individual ever had; deceased siblings are also to be listed. These data are used to construct our variables on the number and sex composition of the individual's siblings.

Information on birth order is imperfect in these data. If the individual reports one sister or one brother, s/he is asked if that sibling is older. However, if the individual reports more than one sister, s/he is asked "were any sisters older than you?" The same questions were asked regarding brothers. Thus, it is possible to determine whether the individual is the oldest in family sizes, but specific birth order can only be determined in two-child families or three-child families so long as the other two children are not of the same sex. We use an indicator variable equal to one if the individual is the oldest.

Hourly Earnings. Log hourly earnings is created from two variables in the PSID. First, respondents are asked whether they are paid a salary or by the hour on their main job (V11653 for heads, V12016 for wives). If paid by the hour, this wage rate is recorded (V11657, V12020). If paid by salary, the wage rate (V11654, V12017) is reported by the PSID: the amount is converted to an hourly rate based on 2000 hours per year if the respondent gave an annual figure, or 40 hours per week if the respondent gave a weekly figure. Our log hourly earnings variable contains only information on earnings from the main job and excludes overtime earnings.

National Longitudinal Survey of Women

For women aged 30–44 in 1967, followed from 1967 through 1984, the NLSW provides information pertaining to the family in which the individual was raised. We used the merged 1967 through 1984 data files. Most of the information we use is from the original questionnaire asked in 1967, although some information was not gathered until later.

Years of Completed Education. We use information on respondent's highest grade completed and age as reported in 1967.

Family Background Variables. In 1967 the respondent was asked about her environment at age 15, including information about mother's and father's highest grade completed, father's occupation, and mother's employment status. From this we constructed dichotomous variables: one indicating that the respondent's father was a professional, one indicating that the respondent's father was a laborer, and one indicating that the respondent's mother was employed. When information on mother's and father's years of completed education was missing, we assigned the mean level of education for mothers and fathers to that observation and included an indicator variable to note this replacement.

Questions were asked in 1967 about the first ten siblings who lived "outside the household," including their birth dates, sexes, and highest grades completed. The respondent was asked in 1977 how many siblings she had ever had. We use a combination of these two pieces of information to calculate number and sex of siblings. We rely only on sibling sex composition, due to the large number of missing values in siblings' birth and years of education data. For all siblings with nonmissing information on sex, we count up the number of sisters and brothers. We then remove those respondents for whom this count of the number of siblings is not the same as the "number of siblings" reported in 1977.

Current Population Survey, November 1989

Years of Completed Education. Using information from Attachment 6 (Adult Interview Data), we construct variables on individual characteristics: age, race, sex, marital status, labor force status, and education. We constructed a "years of completed education" variable using two pieces of information. First, the individual is asked what was the highest grade that s/he attended; the possible responses are zero through eighteen. Then the individual is asked whether s/he completed that grade. If the individual completed the grade, then we take the highest grade attended as the years of completed education. If the individual did not complete that grade, then the years of completed education is the highest grade attended minus one.

Family Background Variables. Information on the individual's siblings is from Attachment 9, the "November 1989 Language, Immigration, and Emigration Supplement (Adult Record)." The individual is asked whether s/he has "any living natural parents, brothers, sisters, or children." If the answer to this question is yes, then s/he is asked specifically if s/he has living parents, brothers, sisters, or children using four different questions. If the answer to any of these questions is coded as "1," then the respondent is asked how many of each type of relative are still living. The possible answers are one, two, three, and four or more. This variable may be coded as "blank" (-1) or "no response" (9). These codes indicate that the person had no such sibling, or did not respond to the question. We use the other two pieces of information, described above, to determine whether a "0" or a missing value is appropriate in each of these cases.

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