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Does Increasing Women's Schooling Raise the Schooling of the Next Generation?

By JERE R. BEHRMAN AND MARK R. ROSENZWEIG*

Widely held conventional wisdom is that an important return to investments in women's schooling is manifested in the increased schooling of the next generation. Moreover, it is also believed that increasing women's schooling has a greater beneficial educational impact on children than increasing men's schooling.[1] Indeed, most studies from a variety of countries report a significant positive and robust relationship between women's schooling and the schooling of their children (Behrman, 1997).

There are two fundamental problems with the findings on intergenerational schooling "externalities." First, more "able" mothers may obtain more schooling, consistent with the literature on ability "bias."[2] If schooling or earnings ability is genetically transmitted to their children, the intergenerational schooling association may merely reflect that more able women, who have more schooling, have more able children, who obtain more schooling. Second, even among mothers with the same abilities, those with higher levels of schooling may have children with greater academic and labor-market performances due to assortative mating. More schooled women in almost all societies marry more schooled men, and they thus marry more able men as well, given own ability-schooling correlations.

The challenge is to obtain an estimate of the intergenerational effects from increasing the *overall* level of women's schooling, which would leave existing distributions of abilities and marital matches essentially unchanged, from data in which there is sorting by schooling and unmeasured characteristics in the home and in the marriage market. We use new data on MZ (monozygotic or identical) female and male twins to estimate the impact of increasing the level of maternal and paternal schooling on child schooling that takes into account the existence of unmeasured heritable traits and marital sorting and thus the possibility of intergenerational "ability bias." These data yield within-twin estimates of the returns to schooling in the labor market that are similar to those from other twin-based earnings studies and cross-sectional estimates that are consistent with previous studies of the impact of parental schooling on child schooling attainment. However, when twinning is exploited to estimate intergenerational schooling effects, the results are strikingly different. In particular, controlling for women's earnings and childrearing ability endowments and the endowments and schooling of their husbands leads to a marginally *negative,* rather than a significantly positive, coefficient for mother's schooling in the determination of child schooling attainment. In contrast, controlling for endowments has little impact on the estimated positive and statistically significant coefficient of father's schooling.

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[1] See, for example, James J. Heckman and V. Joseph Hotz (1986 p. 532), T. Paul Schultz (1993 p. 74), Robert Haveman and Barbara Wolfe (1995 p. 1855), Anne M. Hill and Elizabeth M. King (1995 p. 25), and Duncan Thomas et al. (1996 p. 14).

[2] Several recent studies have used identical twins to control completely for genetic and shared home environment endowments (Orley Ashenfelter and Alan Krueger, 1994; Behrman et al., 1994; Paul Miller et al., 1995; Ashenfelter and Cecilia Rouse, 1998; Behrman and Rosenzweig, 1999; Rouse, 1999). For all but one of the samples used, the estimates indicate upward "ability" biases.

I. Earnings, Schooling Investment, and Assortative Mating

We begin by decomposing the standard earnings function into components associated with schooling, post-school experience, and preschool endowments. In particular, we assume that the log earnings H_{ij} for the ith member of family j is linearly related to his/her schooling S_{ij}, to work experience E_{ij}, to an unobserved heritable earnings endowment h_{ij}, and to an orthogonal earnings term v_{ij}:

$$(1) \qquad H_{ij} = \beta S_{ij} + \beta_E E_{ij} + hj^M + v_{ij},$$

where β and β_E are the earnings effects of schooling and experience, respectively. The well-known problem of identifying β empirically is that S_{ij} is likely to be correlated with the unobserved endowment.[3]

Consider a linear reduced-form equation determining the schooling of i in family j:

$$(2) \quad S_{ij}^c = \delta_1 S_j + \delta_2 S_j^s + \Gamma_1 h_j + f_j + \Gamma_2 h_j^s + \varepsilon_{ij}^c,$$

where the superscript c denotes that the individual is the child in family j, S_j is the schooling of the mother, S_j^s is the schooling of the father, the h's are the earnings endowments of the two parents, ε_{ij}^c is a child-specific characteristic, and f_j is an endowment of the mother expressing her talent for childrearing.

Equation (2) is a reduced form that is consistent with many models, dynamic or static, of household resource allocations. It relates child schooling attainment to the initial at-marriage endowments of the parents, which influence the choice of resource investments made during the formative years of the child. The δ coefficients measure the effects of changing parents' schooling on child schooling, net of changes in parent endowments and thus that part of the child endowment correlated with parents' schooling. They thus reflect parental skill in parenting, time allocation effects, and pure income effects. The Γ coefficients for the two parental earnings endowments also reflect parental income and time allocation effects on child outcomes, but reflect endowment heritability as well.

Identification of the effects of parents' schooling on child's schooling using least squares must assume either that the Γ coefficients are zero or that the unobserved endowments of the parents are uncorrelated with parental schooling. There are two reasons for there to be correlations between parent schooling and heritable endowments: First, a parent's schooling will be correlated with his/her own endowment if (2) holds for all generations and the Γ are nonzero. Second, the endowments of the two parents will be correlated with each other's endowments and schooling due to nonrandom matching in the marriage market. Equations (3a) and (3b) relate the schooling and earnings endowment of the father to the schooling, earnings endowment, and childrearing endowment of the mother:

$$(3a) \qquad S_j^s = r_1 S_j + r_2 h_j + r_3 f_j + e_{ij}$$

$$(3b) \qquad h_j^s = b_1 S_j + b_2 h_j + b_3 f_j + u_{ij}.$$

In these assortative mating equations, r_1 is the mother's schooling effect on her spouse's schooling S_j^s, r_2 is the effect of the mother's earnings endowment on the spouse's schooling and so on, where e_{ij} is a stochastic term. Thus, the parameter r_1 indicates whether there is positive (negative) assortative mating on parents' schooling, net of endowments. Note that if r_2 or r_3 is nonzero and the schooling of the mother is correlated with her endowments then the difference between the estimates of r_1 obtained from the cross section and obtained by estimating (3a) across identical twins is indicative of the extent to which there is assortative mating by unobservable endowments.

We now consider whether we can identify δ_1, the effect of the mother's schooling on her child's schooling, if the mother is an identical twin and we have information for each twin-pair on both parents' schooling, her child's school-

[3] E_{ij} may also be correlated with the own endowment and with the spouse endowment. We assume that most of the work experience of the parents of older children was acquired after marriage and is jointly determined with child investments.

ing, and the earnings of the father.[4] Note that simple differencing of equation (2) across mothers who are identical twins eliminates, by assumption, the mothers' common earnings and childrearing endowments h and f, but there generally will still remain, as a source of bias, the difference in the fathers' earnings endowments. With spouse's schooling excluded from (2), the within-MZ "parent" estimator does answer the question of how an increase in an individual's schooling affects her/his child's characteristics inclusive of the effects on whom he/she marries. But this does not answer the policy question of how the schooling of children would change if the schooling of all women were increased, for the same distribution of available spouses. It also does not answer the question by how much children's schooling increases when a mother in a given marriage subsequently increases her schooling.

A possible remedy for the missing father endowments would be to include his earnings in (2). But, because schooling and earnings are positively correlated, the estimate of the father's schooling effect on his children's schooling is biased downward if his earnings are included in (2). Among fathers with the same earnings, those with higher levels of schooling must have lower endowments. It is thus necessary to remove the effect of spouse schooling from spouse earnings. To do this we obtain estimates of β and β_E that are uncontaminated by own endowment bias from a sample of MZ twins, assuming that the returns to schooling and work experience and the distribution of earnings shocks are the same for twins and for nontwins.

The residual obtained by subtracting the ("true") effects of schooling and experience from earnings contains, however, both the endowment h and the "noise" error v. If v is mostly measurement error or is an independently and identically distributed (i.i.d.) shock then earnings net of schooling effects measure endowments with error, leading to bias in all coefficients if (true) endowments and schooling are correlated. We thus construct a measure of the endowment that nets out the noise term:

$$h_j^s = H_j^s - (\beta S_j^s + \beta_E E_j^s + v_j^s). \tag{4a}$$

Alternatively, v may reflect post-schooling persistent earnings factors. Because by assumption any true earnings determinants embedded in v are orthogonal to own schooling and are not heritable, exclusion of v from (4a) would not bias the estimated effect of the father's schooling on his children's schooling unless couples sort on v in the marriage market. To assess how sensitive the results are to the treatment of the error term, we therefore construct an alternative measure of the spouse endowment,

$$h_j^s + v_j^s = H_j^s - (\beta S_j^s + \beta_E E_j^s). \tag{4b}$$

This measure is appropriate if both the "noise" component of v is small and couples at marriage have good information on their future earnings based on observations of v.

Finally, what does information on pairs of MZ-twin fathers contribute? If unmeasured "mothering" endowments vary across mothers and covary with their earnings endowments, differencing (2) across pairs of MZ fathers and controlling for the earnings endowments of the mothers still leaves some variation in mother's childrearing endowments. If the mother's talent in mothering is positively correlated with the schooling of the father in the marriage market, the within MZ-twin father estimate of the effect of variation in the father's schooling, net of the earnings endowment of the mother, will be upward biased. If fathers contribute less than mothers to childrearing, we should find that the father's schooling effect on child's schooling estimated using the within-mother MZ estimator will be less than that obtained using the within-father MZ estimator.

II. Data

We use data obtained from a new mail survey of a subset of the twins from the Minnesota Twin Registry (MTR). The survey instrument was designed by us and Paul Taubman in collaboration with the Temple University Institute of Survey Research. The MTR is the largest birth-record-based twin registry in the United States, assembled over the 1983–1990 period starting with birth records on all twins (both

[4] An Appendix available from the authors contains a more complete discussion of identification.

monozygotic, MZ, and dizygotic, DZ) born in Minnesota in between 1936 and 1955, with biographical data currently on about 8,400 of the 10,400 surviving intact twin pairs (D.T. Lykken et al., 1990).

The MTR staff obtained from the Minnesota State Health Department all birth certificates reporting multiple births. Then, through an extensive process, they located over 80 percent of the twins and sent them a four-page Biographical Questionnaire (BQ). Our survey instrument was mailed out between May and November 1994 to the 6,638 members of same-sex pairs who had filled out the BQ and for whom the MTR had current addresses. The questionnaire elicited information on the families of the twins, including the twins' spouses, the twins' parents, and the twins' children. Three thousand six hundred eighty twins returned valid questionnaires. Of this set, the number of *pairs* of twins for whom we obtained completed questionnaires was 1,325, of whom 744 were MZ-twin pairs.[5]

There are a number of features of the data that are particularly relevant to the analysis of the impact of parental schooling and endowments on child schooling. First, there is information on schooling attainment for the MZ-twins respondents, their spouses, and the four oldest children of the twins, including information on expected schooling for children who had not completed their schooling. Second, information was obtained on earnings on the last job and on actual post-school cumulative work experience for respondents and spouses, rather than only on earnings in the year prior to the survey and current work time. A well-known problem in analyzing wages of women is that many women choose not to be in the labor force for some portion of their working lives and that such labor-force participation may be selective. Only 82 percent of the women in the sample, for example, worked in 1993. But 97 percent of the women in the sample worked at some point in their lives, 91 percent in the five years prior to our survey.

Finally, it is well known that random measurement error in a regressor variable biases regression coefficients and that schooling reports measure inaccurately true schooling (William T. Bielby et al., 1977). Moreover, within-sibling (twin) estimates are likely to suffer more from measurement error than individual estimates (John Bishop, 1976; Zvi Griliches, 1979). Ashenfelter and Krueger (1994) emphasize strongly the importance of measurement error in within-twin estimates for schooling. In the case in which true schooling S_{ij} is measured with random error, identification of parameters of interest can still be achieved if there are multiple measures of schooling whose measurement errors are not correlated. In our data we have two measures for each respondent's schooling: (i) schooling reported by the respondent, and (ii) a report by the respondent's twin on the respondent's schooling. We allow the error in the own report of a twin and that in his/her cross-twin report to be potentially correlated, as in Ashenfelter and Krueger.

We have, however, only one report for the schooling of each of the spouses, which is provided by the twin respondent. It is possible, given the care individuals take in selecting their mates, that the accuracy of own and spouse schooling knowledge is similar. But in many cases spouses are chosen after schooling is completed, in which case the accuracy of reports on spouses' schooling may be less. We explore the sensitivity of our results to measurement errors in schooling by estimating (2) under three assumptions: no measurement errors in schooling, measurement errors in spouse and own schooling have identical variances, and measurement errors in the respondent-reported spouse schooling have the same variance as that in the twins' reports of their twin's schooling.

III. Estimation of the Determinants of Adult Earnings

As noted, a key ingredient in estimating the effect of parental schooling on children's schooling is the estimation of the parameters of the earnings relationship (1). The earnings

[5] It is not likely that this twins sample is completely representative of all United States' males and females belonging to the same birth cohorts. However, a comparison of the earnings and schooling distributions of our sample with those of all individuals in the same birth cohorts in Minnesota and neighboring states in which most of the MTR twins reside according to the 1990 U.S. Census revealed few differences (Behrman and Rosenzweig, 1999).

TABLE 1—ESTIMATES OF THE DETERMINANTS OF LOG EARNINGS, BY TWINS SAMPLE: MALE AND FEMALE MZ TWINS

Sample	Minnesota Twin Registry Sample, 1994			Twinsburg Ohio Annual Twins Festival Samples, 1991–1993, 1995 (Ashenfelter and Rouse, 1998)		Australian Twin Register, 1980–1982, 1988–1989 (Miller et al., 1995)	
Estimation Method	OLS	Within-MZ	Within-MZ + Instruments	Within-MZ[b]	Within-MZ + Instruments[b]	Within-MZ[c]	Within-MZ[c] + Instruments[c]
Schooling	0.122	0.0885	0.104	0.078	0.100	0.025	0.045
	(18.4)[a]	(6.77)	(5.76)	(4.33)	(4.35)	(4.92)	(4.87)
Lifetime work experience	0.0128	0.00948	0.00983	—	—	—	—
	(6.87)	(3.81)	(3.88)				
Female	−0.359	—	—	—	—	—	—
	(9.47)						
Number of twins	1,462			666		1,204	

[a] Absolute value of t-ratio in parentheses.
[b] Other variables in specification: tenure in last job, in union, married.
[c] Other variables in specification: married.

equation we estimate is based on 731 twin-pairs for whom we have valid earnings data. We allow schooling to be measured with error and make use of the cross-twin reports of schooling to eliminate the bias caused by measurement error. In so doing we obtain estimates of the variances of the own and cross-twin schooling measurement errors. We use these to identify the effects of both spouses' schooling on the children's schooling variables when each spouse's schooling is measured with error. In addition to using the estimates to correct for measurement errors in schooling, we use the parameter estimates obtained from (1) to construct the two measures of the at-marriage endowments of the spouses, given by (4a) and (4b).

The first three columns of Table 1 report OLS, within-MZ pair, and within-MZ pair, with measurement-error correction, estimates of the effects of schooling and actual work experience on the log of full-time earnings from our MZ-twins sample. All three estimates indicate that both schooling and work experience are statistically significant determinants of log earnings, with experience returns about one-tenth of those of schooling returns. Comparison of the results obtained from these different estimators indicate that there is a positive correlation between the unobserved earnings endowment h and schooling and work experience, so that the OLS estimates overstate schooling and experience returns, and that measurement error in schooling biases downward the within-MZ estimates of schooling returns. The estimates of the measurement-error variances indicate that measurement errors represent 6.7 percent and 8.8 percent of the true variances in reported schooling for own and cross-twin reports, respectively. As expected, the own report error variance is less than that of the cross report, and the difference is statistically significant ($\chi^2(1) = 3.81$; $p = 0.052$).[6] The estimates also indicate that the variances in the endowment h and the random component v account for about 20 percent and 45 percent of the total variance in log earnings, respectively.

The last four columns of Table 1 report, for comparison, the within-MZ estimates (with and without correction for measurement error) from two other recent studies based on twins samples—samples based on twins attending the

[6] The estimated correlation between own and co-twin errors, ρ_w, is not significantly different from zero. In Behrman and Rosenzweig (2000b), we show that the within-MZ estimates of the earnings functions are not sensitive to a variety of assumptions about measurement errors in work experience and are not statistically significantly different between men and women.

TABLE 2—ESTIMATES OF THE EFFECTS OF FEMALE SCHOOLING ON HUSBAND'S SCHOOLING: MARRIED MZ FEMALE TWINS[a]

Cross Section	Within-MZ	Within-MZ + Instruments
0.664	0.243	0.385
(14.4)[b]	(2.16)	(2.12)

[a] Number of twins = 600.
[b] Absolute value of t-ratio in parentheses.

TABLE 3—CHARACTERISTICS OF PARENTS AND CHILDREN IN CURRENTLY MARRIED MZ-TWINS SAMPLES WITH ONE CHILD ≥18

	MZ Female Twins	MZ Male Twins
Mother's schooling	13.6	13.8
	(2.19)[a]	(2.06)
Father's schooling	13.7	14.6
	(2.57)	(2.17)
Mother's earnings	21679	22941
(annualized)	(13028)	(15945)
Father's earnings	41007	43276
(annualized)	(57289)	(32048)
Child age	23.6	22.2
	(6.99)	(6.92)
Child schooling	14.8	15.1
	(2.35)	(2.38)
Number of twins	424	244

[a] Standard deviation in parentheses.

Twinsburg Ohio Annual Twins Festivals (Ashenfelter and Rouse, 1998) and the Australian Twin Register (Miller et al., 1995). As can be seen, our within-MZ estimates are quite similar to those obtained from the other U.S.-based twins sample for a similar time period. That study and our estimates indicate a return to schooling, corrected for measurement error, of 10 percent. This contrasts with an error-corrected estimated return to schooling of less than 5 percent in the Australian sample.

IV. Assortative Mating and Intergenerational Schooling Relationships

A. *Assortative Mating*

Our estimates of the earnings determinants indicate a relationship between own earnings endowments and schooling. We now look at whether there is a relationship between own endowments and the spouse's schooling by estimating the assortative mating equation (3a) in terms of schooling using a subsample of the female MZ twin-pairs in which both twins were married. Estimates obtained using OLS, within-MZ pair, and within-MZ pair, with correction for measurement-error estimators, are reported in Table 2 for this sample of 600 twins. The set of estimates indicates that the OLS estimates overstate the schooling effect on spouse schooling and that measurement error biases downward significantly the within-MZ estimate, just as for the estimates of own earnings effects of schooling in Table 1. The difference between the within-MZ and the OLS estimates of the effects of own schooling on spouse's schooling, however, are even more dramatic than they are for the effects of own schooling on own earnings. The OLS estimates indicate that a one-year increase in schooling for a woman increases the schooling of the spouse she attracts by two-thirds of a year. Netting out endowment effects by differencing across MZ twin-pairs, and correcting for measurement-error effects indicates that a woman of given endowments who increases her schooling by one year would actually only attract a mate with less than 0.4 more years of schooling, 42 percent less than indicated by the cross-sectional association between the schooling of spouses. Clearly there is assortative mating by "endowments" that are correlated with schooling. The question is whether these unobservables obscure the relationship between parental schooling and children's schooling.

B. *Intergenerational Schooling Effects*

To estimate the parental schooling effects on their children's schooling taking into account the role of unobservables, we use subsamples of the MZ twins that include 424 (244) individuals from currently married female (male) MZ twin-pairs in which each twin in the pair was married and had at least one child aged 18 or older. Table 3 provides the means and standard deviations for the key variables in the twin mothers' and twin fathers' subsamples. As can be seen, the characteristics of the couples in both sam-

TABLE 4—ESTIMATES OF THE EFFECTS OF MOTHER'S AND FATHER'S SCHOOLING ON CHILDREN'S SCHOOLING: MARRIED FEMALE MZ TWINS

Variable/Estimation Procedure	Cross Section	Cross Section	Cross Section	Within-MZ	Within-MZ	Within-MZ	Within-MZ	Within-MZ
Mother's schooling (δ_1)	0.332 (6.88)[a]	0.137 (2.73)	0.133 (2.64)	−0.245 (1.69)	−0.274 (1.89)	−0.263 (1.82)	−0.263 (1.82)	−0.199 (1.19)
Father's schooling (δ_2)	—	0.286 (6.01)	0.251 (5.34)	—	0.133 (1.87)	0.115 (1.59)	0.141 (1.97)	0.173 (1.94)
Father's log earnings	—	—	0.504 (3.21)	—	—	0.279 (1.34)	—	—
Father's log earnings ($\beta_1 S + \beta_2$ experience)	—	—	—	—	—	—	0.273 (1.31)	—
Father's log earnings ($\beta_1 S + \beta_2$ experience $+ v$)	—	—	—	—	—	—	—	0.558 (1.04)

[a] Absolute value of t-statistic in parentheses.

ples are similar. Given the different roles of men and women in childrearing on average, however, we do not expect the two samples to provide identical within-MZ estimates of parental schooling effects on the schooling of children, as noted.

Table 4 reports, for different specifications and estimation procedures, the estimates of the effects of mother's and father's schooling on the schooling of the child obtained from the subsample of married MZ-twin mothers. The first three columns of estimates are obtained under the assumption that unobserved endowments are uncorrelated with the schooling measures and thus are comparable to the cross-sectional regression estimates that dominate in the literature. The results are conventional—the mother's schooling has a positive and significant relationship with her child's schooling, whether or not her husband's schooling is included in the specification. Inclusion of the husband's schooling level reduces by more than half the maternal schooling coefficient, however, reflecting assortative mating on schooling. Moreover, the husband's schooling has a stronger partial effect on children's schooling than does the wife's schooling. The difference is statistically significant at the 0.01 level. Inclusion of the husband's earnings in column 3 as expected lowers the estimated husband schooling effect, but it is still almost twice that of the mother. Our cross-section results are comparable to those in the literature. We have surveyed 33 sets of estimates from 11 studies on the associations between parental and child years of schooling in the United States (Behrman and Rosenzweig, 2000a). The median estimate of the association between child and mother's schooling is 0.12 years of child schooling for every additional year of mother's schooling (we get 0.14) and 0.15 years of child schooling for every additional year of father's schooling (we get 0.29).

Estimates using the within-MZ mother estimator of the gross effect of mother's schooling on children's schooling, which eliminates the potential influence of mother's endowments that may be correlated with her schooling and that of her spouse, are reported in the fourth column of Table 4. Comparison of the estimates in columns 1 and 4, both of which exclude the husband's schooling and earnings, suggests that the positive relationship, gross of husband's endowments, between children's and mother's schooling is due solely to the correlation between her unobserved endowments and maternal schooling—when the influence of her endowments is eliminated, the gross maternal schooling effect is negative. Thus, among mothers with essentially the same preschool human capital (genetics, family background), those who obtained more schooling, gross of the effect of their schooling on whom they married, had children who obtained less, or at least no more, schooling. Eliminating, in addition to the women's own endowment, the effect of the women's schooling on the schooling of her husband in the marriage market by adding the husband's schooling to the

TABLE 5—ESTIMATES OF THE EFFECTS OF MOTHER'S AND FATHER'S SCHOOLING ON CHILDREN'S SCHOOLING: MARRIED MALE MZ TWINS

Variable/Estimation Procedure	Cross Section	Cross Section	Cross Section	Within-MZ	Within-MZ	Within-MZ	Within-MZ	Within-MZ
Mother's schooling (δ_1)	—	0.254 (3.23)	0.242 (2.98)	—	0.0432 (0.31)	0.0335 (0.24)	0.0160 (0.11)	0.0149 (0.54)
Father's schooling (δ_2)	0.466 (7.40)[a]	0.325 (4.69)	0.327 (4.71)	0.356 (2.28)	0.344 (2.12)	0.340 (2.10)	0.350 (2.16)	0.346 (1.89)
Mother's log earnings	—	—	0.0771 (0.32)	—	—	0.257 (0.71)	—	—
Mother's log earnings ($\beta_1 S + \beta_2$ experience)	—	—	—	—	—	—	−0.202 (0.82)	—
Father's log earnings ($\beta_1 S + \beta_2$ experience + v)	—	—	—	—	—	—	—	0.150 (0.75)

[a] Absolute value of t-statistic in parentheses.

specification has little effect on the maternal schooling coefficient. Taking into account the earnings endowment of the husband, whether measured by actual earnings or by actual earnings less the influence of his schooling and work experience, raises the maternal schooling coefficient δ_1, but it is still negative (columns 6 and 7). Eliminating the nonendowment component of earnings v increases the estimate of δ_1 still further (column 8), and for this estimate one cannot reject the hypothesis that an increase in maternal schooling within marriage has no effect on her children's schooling.

The estimate of δ_2, the father's schooling effect on children schooling, is positive in all specifications, but is also sensitive to the inclusion and measurement of his earnings endowment. Inclusion of husband earnings reduces the estimate of δ_2 by 14 percent. However, when husband earnings is stripped of the effects of work experience and schooling, leaving only the pre-school endowment and v, the estimate of δ_2 rises by 23 percent. Elimination of post-schooling earnings shocks increases δ_2 by another 23 percent. The point estimate is reasonably precisely estimated but is small, suggesting that an increase in the father's schooling by one year, net of changes in either parent endowments, would raise his children's schooling by 0.17 years, 44 percent less than the cross-sectional estimate.

The estimates of Γ_2 in Table 4, the association between the husband's earnings endowment and the child's schooling, are also positive and are larger when the earnings shock term is removed. However, the coefficients are not precisely estimated. Γ_2 reflects not only income effects but any intergenerational genetic correlation between the father's endowment and that of his child. Estimating the model on the subsample of MZ-twin fathers eliminates completely the influence of the father's heritable pre-school endowments and provides an estimate of the paternal schooling effect on child schooling net of these endowments. Table 5 reports estimates of parental schooling on child schooling for the sample of MZ-twin fathers and parallels Table 4. Here, again, in contrast to the estimated effects of the mother's schooling on child schooling, the positive association between the father's schooling and the child's schooling is robust to controls for all paternal and maternal schooling and (earnings) endowments. The cross-sectional estimate of the paternal schooling effect is positive and statistically significant (as in the sample of female MZ twins), but even the within-MZ estimate of the gross effect of the father's schooling on his child's schooling, reported in column 4, is positive and statistically significant, in contrast to that of mother's schooling. Thus, among men with almost identical family backgrounds and identical genetic makeups, those who obtain

TABLE 6—WITHIN-MZ ESTIMATES OF THE EFFECTS OF MOTHER'S AND FATHER'S SCHOOLING ON CHILDREN'S SCHOOLING UNDER DIFFERENT ASSUMPTIONS ABOUT MEASUREMENT ERROR: PARENT EARNINGS ENDOWMENTS GROSS OF EARNINGS SHOCKS

Sample	Married Female Twins			Married Male Twins		
Measurement-Error Assumption	No Measurement Error[a]	Own Measurement Error = Spouse Measurement Error	Spouse Measurement Error = Cross-Twin Measurement Error	No Measurement Error[c]	Own Measurement Error = Spouse Measurement Error	Spouse Measurement Error = Cross-Twin Measurement Error
Mother's schooling (δ_1)	−0.263 (1.82)[b]	−0.392 (1.23)	−0.394 (1.23)	0.0160 (0.11)	0.00501 (0.20)	−0.00926 (0.37)
Father's schooling (δ_2)	0.141 (1.97)	0.187 (1.97)	0.194 (1.97)	0.350 (2.16)	0.509 (2.42)	0.560 (2.39)
Father's log earnings ($\beta_1 S$ + β_2 experience)	0.273 (1.31)	0.291 (1.09)	0.293 (1.09)	—	—	—
Mother's log earnings ($\beta_1 S$ + β_2 experience)	—	—	—	−0.202 (0.82)	0.183 (0.43)	0.175 (0.40)

[a] Estimates from column 7 of Table 4.
[b] Absolute value of t-statistic in parentheses.
[c] Estimates from column 7 of Table 5.

more schooling have children who obtain more schooling, gross of the effect of assortative mating.

Taking into account the mother's schooling and her more complete earnings endowment hardly changes the paternal schooling estimate. However, as noted, inclusion of measures of the wife's earnings endowments does not eliminate differences in maternal childrearing talents (f_j in the model cannot be identified), which may be correlated with the husband's schooling if there is assortative mating on this endowment. This is suggested by the fact that the estimate of the paternal schooling effect net of only the maternal earnings endowment h in Table 5 exceeds the estimate of the paternal schooling effect net of both the maternal earnings and childrearing endowments h and f in the last column in Table 4. The within-MZ father estimates, nevertheless, replicate the result in Table 4 indicating that there is no effect of increasing the mother's schooling on her children's schooling.

C. *Sensitivity Tests*

Are the estimates obtained of the effects of raising parents' schooling, which relax the assumptions imposed in conventional estimates, sensitive to assumptions about measurement error in schooling? Tables 6 and 7 report the within-MZ estimates of maternal and paternal schooling effects on children's schooling from specifications that include the spouse endowment gross (Table 6) and net (Table 7) of the nonendowment earnings component v obtained under three assumptions about measurement errors in schooling reports: (1) there is no measurement error in either parental schooling variable, the assumption employed in obtaining all of the estimates reported in Tables 4 and 5; (2) the measurement error in self-reports of schooling is the same for respondent reports of spouse schooling; and (3) respondent reports on their spouse's and twin's schooling (cross reports) are equally error prone.

The set of estimates obtained under different assumptions about measurement error in Tables 6 and 7 suggests that the quantitative, but not the qualitative, results obtained are somewhat sensitive to whether schooling reports are assumed to be error free. Ignoring measurement error in schooling reports entirely evidently biases toward zero the estimated effects of both the mother's and father's schooling on children's schooling. This is particularly so for the female sample of MZ-twin pairs, where the estimated effect of raising

TABLE 7—WITHIN-MZ ESTIMATES OF THE EFFECTS OF MOTHER'S AND FATHER'S SCHOOLING ON CHILDREN'S SCHOOLING UNDER DIFFERENT ASSUMPTIONS ABOUT MEASUREMENT ERROR: PARENT EARNINGS ENDOWMENTS NET OF EARNINGS SHOCKS

Sample	Married Female Twins			Married Male Twins		
Measurement-Error Assumption	No Measurement Error[a]	Own Measurement Error = Spouse Measurement Error	Spouse Measurement Error = Cross-Twin Measurement Error	No Measurement Error[c]	Own Measurement Error = Spouse Measurement Error	Spouse Measurement Error = Cross-Twin Measurement Error
Mother's schooling (δ_1)	−0.199 (1.19)[b]	−0.354 (1.14)	−0.356 (1.14)	0.0149 (0.54)	0.0123 (0.39)	0.0123 (0.38)
Father's schooling (δ_2)	0.173 (1.94)	0.193 (1.99)	0.197 (1.98)	0.346 (1.89)	0.471 (1.92)	0.471 (1.91)
Father's log earnings ($\beta_1 S + \beta_2$ experience + v)	0.558 (1.04)	0.520 (0.93)	0.513 (0.91)	—	—	—
Mother's log earnings ($\beta_1 S + \beta_2$ experience + v)	—	—	—	0.150 (0.75)	0.155 (0.76)	0.155 (0.76)

[a] Estimates from column 8 of Table 4.
[b] Absolute value of t-statistic in parentheses.
[c] Estimates from column 8 of Table 5.

maternal schooling increases in absolute magnitude by 50 percent or more when account is taken of measurement error in both respondent and spouse schooling reports. The estimate of the paternal schooling effect also rises by from 14 percent to 38 percent when account is taken of measurement error in schooling. However the estimates are virtually identical in both samples whether the degree of measurement error in own and spouse schooling reports is assumed to be the same or to differ as much as the difference between own and cross-twin reports.

D. *Interpreting the Results*

Our findings thus clearly suggest that, in contrast to conclusions based on cross-sectional estimates, increasing men's schooling would raise the level of schooling of the next generation by a small amount, net and gross of assortative mating, while raising the level of schooling attainment of women would not, and may even lower it. And these results appear to be robust to a range of assumptions about measurement errors in respondent reports of spouse's schooling and to measures of spouse endowments. What is the mechanism? While it is always hazardous to attempt to interpret reduced-form estimates, this pattern of results is consistent with the hypothesis that women's time in the home is a critical determinant of the human capital of children.

We can look at the relationship between a cumulative measure of the home time of the mothers in our sample and the schooling of the marital partners. Based on the information on actual cumulated work experience, we constructed a measure of post-school labor-force participation for each of respondents in the sample—the fraction of years after completing (initial) schooling that was spent in the labor market. We then regressed this measure on own schooling, spouse schooling, and spouse income less the effect of his schooling and own work experience using a sample of married female MZ twins, each of whom had at least one child and was aged less than 50 at the time of the survey.[7] We chose this younger sample of twin mothers, in which on average 60 percent of the years since leaving school was spent in full-time work, because we are

[7] The results are unaffected if v is included in the measure of the husband's earnings endowment.

TABLE 8—RELATIONSHIPS BETWEEN MOTHER'S AND FATHER'S SCHOOLING AND MOTHER'S POST-SCHOOL WORK EXPERIENCE (PROPORTION OF POST-SCHOOLING YEARS WORKED): MARRIED MOTHERS AGED <50

Variable/Estimation Procedure	Cross Section	Within-MZ Twin	Within-MZ Twin (Own Spouse Measurement Error)	Within-MZ Twin (Own Cross-Twin Measurement Error)
Mother's schooling	0.0245	0.0310	0.0532	0.0532
	(2.57)[a]	(1.49)	(1.51)	(1.51)
Father's schooling	−0.0222	−0.0110	−0.0137	−0.0141
	(2.73)	(0.94)	(1.02)	(1.02)
Father's log earnings ($\beta_1 S$	−0.0354	−0.0168	−0.0152	−0.0151
$+ \beta_2$ experience)	(1.33)	(0.49)	(0.44)	(0.43)
Number of twins	328	328	328	328

[a] Absolute value of t-ratio in parentheses.

interested in measuring post-school participation in the labor market while at least some children were living at home. The older the sample, the greater is the fraction of lifetime work time that occurred after children have left home, when such behavior could not have influenced greatly the school attainment of the children.

Table 8 provides cross-sectional estimates, within-MZ estimates, and within-MZ estimates that permit measurement error in schooling of own and spouse schooling effects on the post-school work experience of married women. The cross-sectional results are consistent with most studies of the contemporaneous labor supply of married women, indicating that (i) those women with higher levels of schooling spent a significantly greater fraction of their post-school years in the labor market, for given schooling or earnings of their husbands, and (ii) among married women with the same schooling, those married to a husband with a higher level of schooling or earnings worked significantly less. However, the OLS estimates confound schooling and endowment effects and we want to understand the estimates showing a net negative or zero impact on child schooling of increasing maternal schooling net of endowments. The within-MZ, estimates, although less precisely estimated, suggest that the cross-sectional estimates understate the positive effect of increasing female schooling on their participation in the market within marriage. The point estimates from the measurement-error-corrected within-MZ estimates suggest that the fraction of post-school years in the labor market spent by a married woman with a college education was almost a third higher than that of a married woman high-school graduate. Increased schooling for men, net of endowment effects, does not have any effect on their wives' lifetime work experience, in contrast to the cross-sectional estimates. Raising the levels of female schooling thus would appear to decrease the total amount of time spent in the home by the mother, while raising the level of male schooling would appear to have little effect on her home time.[8]

V. Conclusion

Our results suggest that the positive cross-sectional relationship between the schooling of mothers and their children is substantially biased upward due to correlations between schooling and heritable "ability" as well as assortative mating. Indeed our results indicate that an increase in the schooling of women would not have beneficial effects in terms of the schooling of children. We also find that increased maternal schooling leads to reduced home time for mothers. These findings together are consistent with the notion that the time of women is a significant factor in childrearing. Our findings, however, must be interpreted with care because they are outcome and context specific. It is possible that increased mother's schooling in the same environment leads to other improved

[8] Estimates based on the same sample indicate that changing the schooling of either parent has little effect on the father's labor-force experience.

outcomes for children, such as their health, particularly if improvements in these other outcomes are relatively information intensive rather than time intensive. And it is also possible that in other labor-market contexts and cultures increased women's schooling leads to increased child schooling. Indeed in Behrman et al. (1999) we report strong evidence of that effect in rural India in recent decades, a context in which more schooled women did not appreciably increase their participation in market activities outside the home. Anticipating the consequences of investments in women's schooling thus requires attention to the role that schooling plays in the marriage market as well as to opportunities in the labor market for women.

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