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SCHOOLING, INTELLIGENCE, AND INCOME IN AMERICA: CRACKS IN THE BELL CURVE

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ABSTRACT

One of the best documented relationships in economics is the link between education and income: higher educated people have higher incomes. Advocates argue that education provides skills, or human capital, that raises an individual's productivity. Critics argue that the documented relationship is not causal. Education does not generate higher incomes; instead, individuals with higher ability receive more education and more income. This essay reviews the evidence on the relationship between education and income. We focus on recent studies that have attempted to determine the causal effect of education on income by either comparing income and education differences within families or using exogenous determinants of schooling in what are sometimes called "natural experiments." In addition, we assess the potential for education to reduce income disparities by presenting evidence on the return to education for people of differing family backgrounds and measured ability.

The results of all these studies are surprisingly consistent: they indicate that the return to schooling is not caused by an omitted correlation between ability and schooling. Moreover, we find no evidence that the return to schooling differs significantly by family background or by the measured ability of the student.

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I. Introduction

One of the best documented relationships in economics is the link between education and income: higher educated people have higher incomes. Advocates argue that education provides skills, or human capital, that raises an individual's productivity. Because productivity is reflected in income, education is thus a key determinant of social mobility. Critics argue that the documented relationship is not causal. Education does not generate higher incomes; instead, individuals with higher ability receive more education and more income. In this view education and income are positively correlated because they share a common foundation, individual ability.

The debate over the income-schooling relationship has taken on greater urgency as income inequality in the United States has steadily increased over the 1980s. Advocates support educational programs and urge low-income workers to remain in school in the belief that the gap between rich and poor arises from a lack of skills among the poor. Others believe the gap between rich and poor arises because poor individuals do not benefit as much from additional education as do the rich. According to this view increasing support for educational programs for the disadvantaged will have no effect on the overall income distribution.

This essay reviews the evidence on the relationship between education and income. We focus on recent studies that have attempted to determine the casual effect of education on income by either comparing income and education differences within families or using exogenous determinants of schooling in what are sometimes called "natural experiments." In addition, we assess the potential for education to reduce income disparities by presenting evidence on the return to education for people of differing family backgrounds and measured ability.

The results of all these studies are surprisingly consistent: they indicate that the return to schooling is not caused by an omitted correlation between ability and schooling. Moreover, we find no evidence that the return to schooling differs significantly by family background or by the measured ability of the student.

II. Schooling and Income: The Simple Relationship

The basic relationship between income and education is shown in Figure 1. Figure 1 graphs the average of the logarithm of hourly earnings by the number of completed years of schooling using the *Current Population Survey* (CPS).[1] The slope is fairly flat for those who did not complete a high school education; approximately 13% of the working population. On the other hand, the relationship is much stronger for the 87% with higher levels of educational attainment. For example in 1990 and 1991, high school graduates earned 18% more than high school dropouts with 11 years of schooling. Similarly, those who had completed one year of college earned 8% more than high school graduates. Despite what is sometimes claimed, Figure 1 indicates no tendency for the effect of schooling on earnings to be associated solely with the years in which degrees are awarded. Apparently it is more than the award of a degree that is associated with greater earnings.

It is conventional to summarize the overall relationship between schooling and income by regressing the (natural) logarithm of the hourly wage on years of (completed) education controlling for explanatory variables such as experience, sex, race, and region of the country (Mincer (1974)). The coefficient on the education variable is interpreted as the percentage increase in the hourly wage associated with one additional year of schooling, and is referred to as the "return to schooling."[2]

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[1] The data in Figure 1 are from the 1990 and 1991 merged outgoing rotation group files of the CPS. (These were the last years in which "years of schooling" were reported.) The sample included employed individuals aged 18-67 years old who earned at least $1.00 per hour (in 1994 dollars) and excluded the self-employed. All means were weighted using the earnings weight.

[2] Although labor economists refer to it as the "return to schooling," it is actually just the average percentage difference in mean earnings for each additional year of schooling. As Mincer (1974) shows, if foregone earnings are the only cost of school attendance this is the private rate of return to the investment in a year of schooling. A more detailed calculation of the "return" would incorporate the tuition costs of schooling, as well.

Figure 1. Average Log Hourly Wage by Years of Education

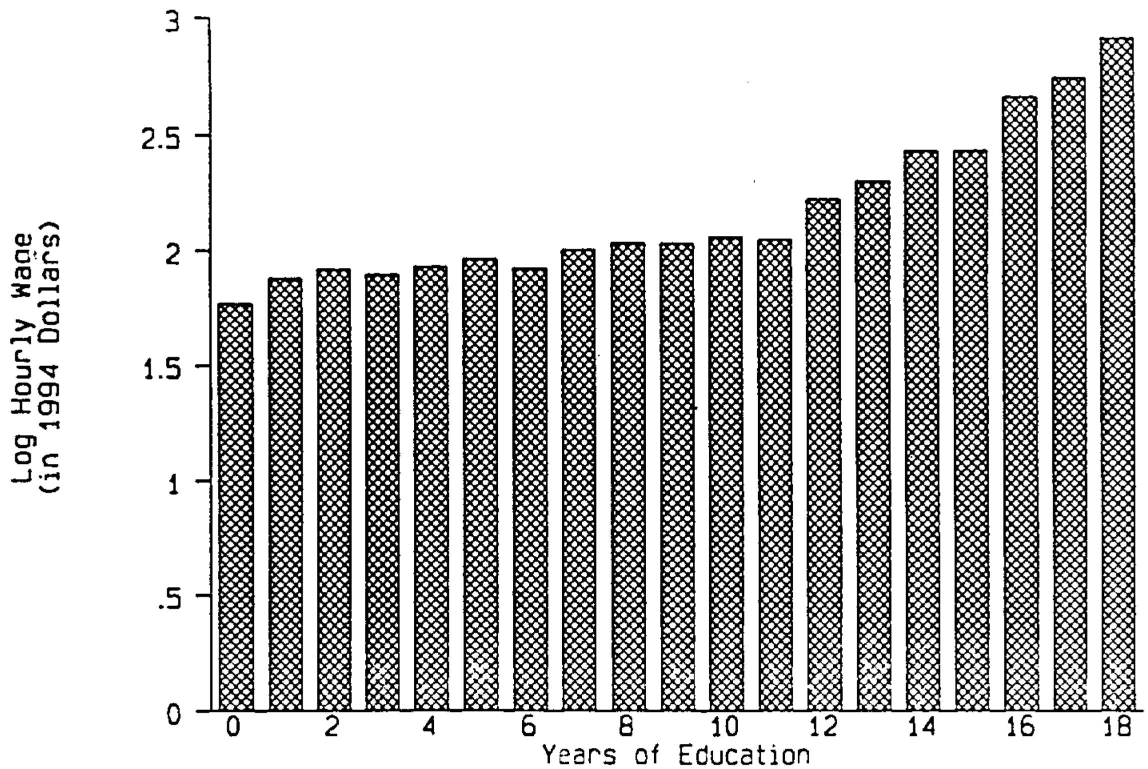

Figure 2 graphs the estimated (cross section) return to education for each of the years from 1979 through 1993.[3] The figure shows the tremendous increase in the value of schooling in the labor market that has taken place throughout the 1980s. A return to an additional year of schooling of 6.2% in 1979 had grown to almost 10% in 1993. This increase in the return to schooling is well-documented, and is a primary source of the increasing income inequality in the United States.[4]

But does the estimated return to schooling reflect the causal effect of schooling on earnings? A nagging concern is that higher ability people get more schooling, and would earn higher wages and salaries even if they had not received the additional schooling. In this case, the schooling-income connection may be a mirage; it is just a symptom of the fact that higher ability people command a premium for their (innate) skills in the labor market. The result is that regression estimates of the return to schooling are upward biased due to "family background" or "ability" bias.

In the past decade several methods have been designed and implemented in order to determine whether the schooling-income connection is causal. Before we turn to a discussion of those analyses, we ask a separate question: What would be the ideal, definitive study? That is, if there were no limitations on our resources, how would we ideally test for whether schooling causes higher wages and salaries? Understanding the basis for an ideal empirical test of the hypothesis that schooling boosts income makes it far easier to understand the other tests that have been proposed.

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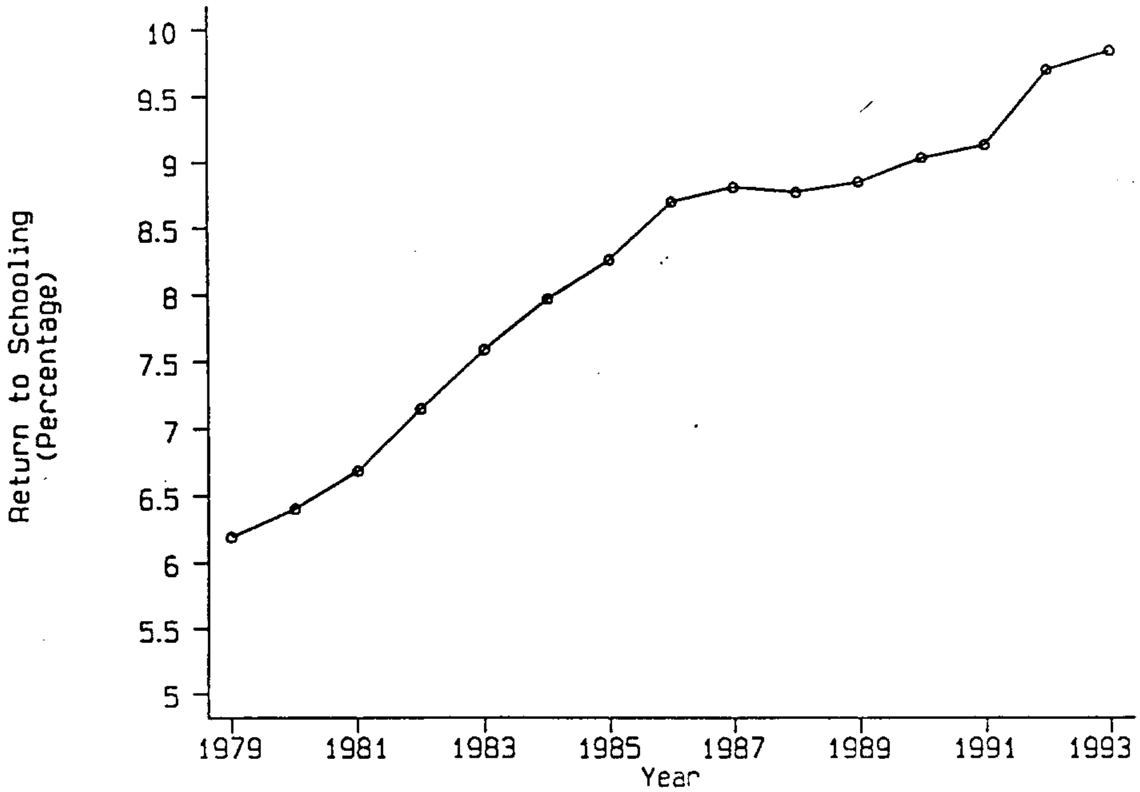
[3] The data in Figure 2 are from the 1979-1993 merged outgoing rotation group files of the CPS. The samples included employed individuals aged 18-67 years old who usually work full-time (more than 34 hours per week) and earned at least one-half of the minimum wage; they excluded the self-employed. All estimates were weighted using the earnings weight.

[4] However, there has also been tremendous growth in within-education income inequality leading researchers to attribute the bulk of the growth to an increase in the demand for "unobservable skills." Just what these "unobservable skills" represent and why the demand for them has changed is a matter of debate.

Figure 2. Estimated Return to Schooling, 1979-1993



III. Schooling and Income: The Ideal Experiment

In principle, the only way to determine definitively whether schooling causes higher incomes is to perform an experiment. In such an experiment, different groups of students would be randomly assigned to different educational levels without regard to their ability or general background. Years later we would compare the incomes of these students. On average the only differences among the students would be the level of their schooling. Contrasts of the earnings of the various groups would, with a large enough sample, provide an entirely credible estimate of the causal effect of schooling on earnings.

Of course, the experiment just described has not been performed, and will not likely be performed in the near future. Some people would object that it would be morally objectionable to deny a potentially valuable education to those who might otherwise have obtained it.[5] As a result, researchers must look elsewhere for convincing non-experimental evidence. Two broad approaches have been taken to address the problem of ability bias. The first compares the wages of workers who have similar genetic and family backgrounds, but who differ in educational levels. A systematic correlation between the educational differences and income differences of such workers is evidence of the link between income and schooling that cannot be a result of common family backgrounds. The second approach looks for a determinant of education that is not also a determinant of incomes (so called "natural experiments").

[5] One way to address this objection is to make sure that no one is denied access. For example, in many developing countries inadequate finances make it impossible to educate all students who wish to attend secondary schools. If students were admitted to secondary schools in part on a randomized basis, it would be possible to perform a credible experiment that would not be objectionable. When people must be denied access to educational opportunities in any case, why not use a randomized allocation system so that we may learn from their experiences?

IV. Schooling and Income: Intra-Family Comparisons

In recent years the availability of new data has made it possible to use sibling pairs to construct new estimates of the return to schooling. Although much of the emphasis in the most recent literature is on careful adjustment of the estimates for problems of measurement error, the methods used are similar to those used by Gorseline(1927), Chamberlain and Griliches (1975, 1977), Olneck (1976), Corcoran, Jencks, and Olneck (1976), and Behrman, Hrubec, and Taubman (1980).[6]

A. Father and Son Comparisons

To see how the use of within-family correlations can identify a causal relationship between schooling and income, consider first the case of fathers and sons. Raised in the same extended family and sharing many similar genetic endowments, fathers and sons are expected to perform far more similarly in the labor market than randomly selected worker pairs. If the father's background and genetic endowments are inherited by the son, then the father and son should have similar earnings if they have similar educational backgrounds. On the other hand, we would expect that if a father is better educated than his son, he would earn a higher wage than his son only if schooling is a causal determinant of earnings.[7]

Ashenfelter and Zimmerman (1997) matched data on fathers and sons for a period in the 1980s using the National Longitudinal Surveys of Youth and Older Men. Using these data, they computed the relationship of the schooling differences to income differences between fathers and sons. Figure 3 is a scatter diagram from their paper that shows this relationship. On the vertical axis is a measure (in ratio or logarithmic scale) of the difference between the hourly wage rate of

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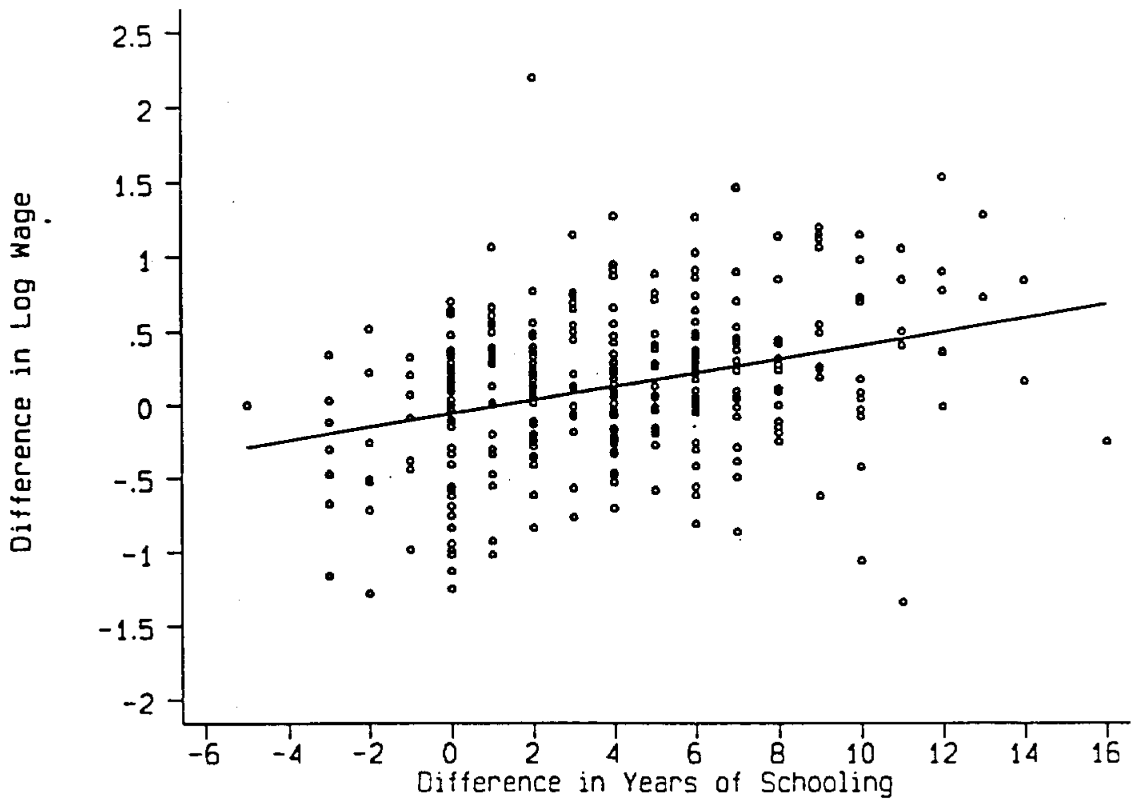
[6] See especially Griliches (1979) for an insightful review of these studies.

[7] A more formal derivation of the empirical framework is outlined in the Technical Appendix.

Figure 3. Father and Son Schooling and Income Differences



each father and his son. On the horizontal axis is the difference between the years of schooling of the father and his son. Each point on the diagram represents one father-son pair; there are 332 such pairs in the National Longitudinal Survey.

As one would expect in an economy where the average schooling level has been growing, fathers have about four fewer years of schooling than sons. As one would also expect in a society which has imperfect generational mobility, fathers with higher education levels tend to have sons with higher education levels. (The correlation coefficient is about 0.4.) This suggests that family background bias leads to overestimates of the casual effect of schooling on income. That is, the simple correlation between the income and schooling of the sons may be the result of the fact that better educated sons also have better connected fathers. If this were the only reason for the correlation between the income and schooling of sons, however, we would also find that the correlation between the difference in the father's and son's education levels and the difference in the father's and son's incomes is negligible.

As Figure 3 indicates, however, this cannot be the entire story. The diagram reveals that there still remains a substantial correlation between the difference in the education level of the father from the son and the difference in their incomes. The slope of the best fitting line in these data indicates that a one year difference in the education levels of father and son translates into about a 5% difference in wage rates. This implies that estimated returns to schooling are not simply a result of the fact that sons with more schooling have fathers with more schooling, too.

B. Sibling Comparisons

Ashenfelter and Zimmerman (1997) and Altonji and Dunn (1996) also implement a within-family estimator of the return to schooling based on sisters and brothers using the National Longitudinal Survey (NLS) and the Panel Study of Income Dynamics (PSID). Table 1 summarizes their results. As Table 1 indicates, an additional year of schooling is associated with a 3.7% to

Table 1

Summary of the Estimated Return to Schooling from Sibling Studies

		Estimated Return to Schooling		
Data	Comparison	Overall	Within-Family	Difference
NLS (1981)[1]	Brothers	5.9% (1.4)	4.8% (1.8)	1.1%
NLS (1982-1984)[2]	Brothers	4.7% (0.5)	3.7% (1.2)	1.0%
PSID (1982-1984)[2]	Brothers	6.2% (0.2)	4.6% (0.5)	1.6%
NLS (1982-1984)[2]	Sisters	7.4% (0.4)	6.3% (1.0)	1.1%
PSID (1982-1984)[2]	Sisters	7.2% (0.2)	4.2% (0.5)	3.0%

Notes: The dependent variable is log hourly wages. Estimated standard errors are in parentheses. The NLS is the National Longitudinal Survey. The PSID is the Panel Study of Income Dynamics.

[1] Ashenfelter and Zimmerman (1997).

[2] Altonji and Dunn (1996). These estimated returns to schooling are evaluated for individuals with no labor market experience.

6.3% increase in earnings depending on the study and the group analyzed.[8]

For comparison, Table 1 also provides estimates of the effect of an additional year of schooling on earnings when we ignore the sibling connections. A comparison of the estimates in columns 1 and 2, which is contained in column 3, indicates the extent to which family background bias contaminates the observed correlation between schooling and earnings. As Table 1 indicates, the simple regression estimates are upward biased by between 15% and 42%. Although part of the correlation between income and schooling may be due to family background characteristics, the intra-family correlation between income and schooling indicates that most of the relationship between income and schooling is due to something else.

Finally, it has been shown that the presence of measurement error in the schooling data introduces a downward bias in the within-family estimates of the effect of an additional year of schooling on earnings (Griliches (1977)). Ashenfelter and Zimmerman (1997) find that the within-family estimate of the return to schooling is downward biased by 25% to 40% due to measurement error. Thus, the estimates in Table 1 almost certainly over-state the extent to which ability or family background is responsible for the observed correlation between schooling and earnings among siblings. Most adjustments for measurement error imply that the upward bias in returns to schooling caused by omitted ability factors is about the same size as the downward bias due to measurement error. Thus, the simpler regression estimates of returns to schooling may well be the most accurate.

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[8] The estimated returns to schooling reported by Altonji and Dunn are evaluated for an individual with zero labor market experience in order to include the standard errors in the table. The comparable estimates, from both data sets, of the return to schooling for those with the panel mean experience (adjusted for family background) are about 6.6% for men and about 7.2% for women.

C. Identical Twins Comparisons

Although ordinary siblings share family backgrounds, and some genetic factors, they may still have considerable differences in genetic ability. If the "genetically superior" sibling obtains more schooling, then the schooling/income correlation within families may simply be a result of the fact that the more able sibling has spent more time in school. One way to resolve this question is to compare the earnings and schooling of identical twins. Identical (monozygotic--one egg) twins are formed when a single, fertilized egg divides. It is generally believed that the division of a fertilized egg occurs at random. Thus, identical twins have identical genetic endowments. As with the other family comparisons, a simple test of whether genetic ability causes the schooling/income correlation can be made by comparing the incomes of identical twins with different schooling levels. If better educated twins earn more, the correlation between income and schooling cannot be a result of genetic differences, for among identical twins there are none.

For the past four years, we have collected new data on twins in order to study the role of genetic endowments in the determination of income. To do this at reasonable cost, we have interviewed twins who have assembled for the National Twins Festival in Twinsburg, Ohio. We administered a survey similar to the Current Population Survey to about 1,000 twins in a brief, but intensive, three day period. The data we have collected provide a unique and rich opportunity to test whether the correlation between income and schooling that we observe among twins is a result of genetic endowments. These data are probably the closest it is possible to come to an experiment in which schooling is assigned randomly with respect to genetic endowments.

Our main findings are displayed in Figure 4 and Table 2. Figure 4 is a scatter diagram where each point represents a single pair of twins. The vertical axis represents the difference (in ratio terms) between the incomes of identical twins, while the horizontal axis represents the difference between the schooling levels of the twins. As one would expect, the diagram indicates (by the concentration of observations at zero on the horizontal axis) that in the most typical case

Figure 4. Intrapair Return to Schooling, Identical Twins

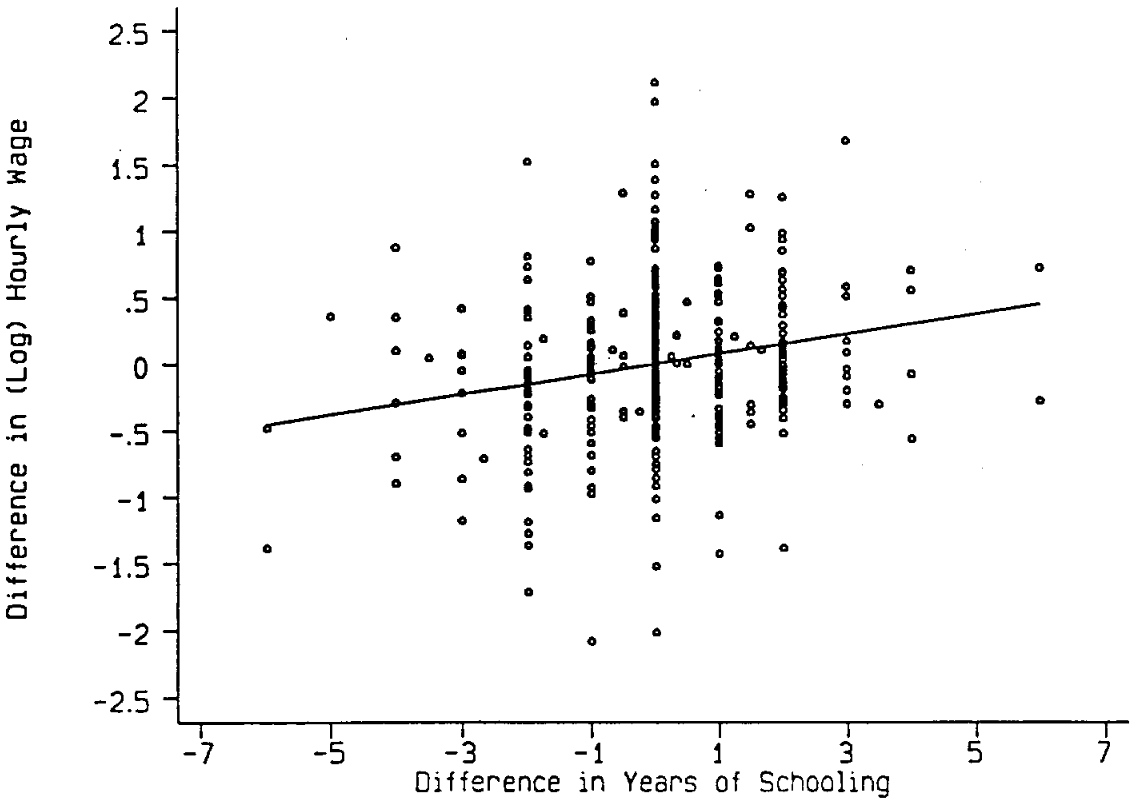

Table 2

Estimated Return to Schooling Using Identical Twins

	Return to Schooling		
		Within-Twin	
Data (Year of Wages)	Overall	OLS	IV
NAS-NRC (1973)[1]	7.6%	3.1%	NA
	(0.4)	(0.7)	
NAS-NRC (1973)[1,a]	9.4%	3.5%	5.0%
	(1.1)	(0.4)	(2.9)
Minnesota (1980)[1]	5.5%	4.1%	NA
	(0.2)	(0.4)	
Australia (1980-1982, 1989)[2]	6.4%	2.5%	4.5%
	(0.2)	(0.5)	(0.9)
Princeton (1991)[3]	8.7%	11.2%	13.2%
	(1.5)	(2.3)	(2.8)
Princeton (1991-1993)[4]	10.6%	7.8%	9.9%
	(0.9)	(1.7)	(2.1)

Notes: Standard errors are in parentheses.

[a] Based on the subset of twins for which at least one child each of both twins reported their father's schooling.

[1] Behrman, Rosenzweig, and Taubman (1994) -- Men only; NAS-NRC is the National Academy of Sciences-National Research Council; the dependent variable is the logarithm of annual earnings.

[2] Miller, Mulvey, and Martin (1995) -- Men and Women; the dependent variable is the logarithm of annual earnings.

[3] Ashenfelter and Krueger (1994) -- Men and Women; the dependent variable is logarithm hourly wages.

[4] Ashenfelter and Rouse (1998) -- Men and Women; the dependent variable is logarithm hourly wages.

the twins have the same education level. The diagram also makes clear that there is a considerable correlation between income differences and schooling differences. In these data, the better educated twin earns about 8% more for each extra year he (or she) attains compared to his (or her) twin.

More detail is contained in Table 2. The second column of the Table provides the estimated effect of schooling on earnings within twin-pairs. As the table indicates, a one-year schooling difference between twins is associated with about an 8% greater wage for the more highly educated twin.

Table 2 also provides the estimate of the effect of an additional year of schooling on earnings when we ignore the twin connections. A comparison of the estimates in columns 1 and 2 indicates the extent to which genetic endowments contaminate the observed correlation between schooling and earnings. As the table indicates, ability bias accounts for about 25% of the simple estimate of the effect of schooling on income. Again, although some part of the correlation between income and schooling may be due to family background or genetic endowments, the intra-twin correlation between income and schooling indicates that most of the relationship between income and schooling must be due to something else.

In order to validate the data on the education level of each twin, we separated the twins during our interviews and asked each twin about his (or her) own education level as well as the education level of his (or her) twin. We can, therefore, correct for measurement error by instrumenting for the difference in the twins' own-reports of their schooling levels using the difference in the twin-reported schooling levels as an instrumental variable (assuming that the twins' reports of each other's schooling levels are uncorrelated.) The estimated effect of a year of schooling on wages allowing for measurement error is about 10%, as reported in the third column of Table 2. Failure to account for measurement error in schooling in within-twin comparisons apparently leads to about a 30% downward bias in the estimate of the effect of schooling on earnings.

Table 2 also contains data from three other studies of twins, one of which uses data from Australia.[9] Although the magnitude of the estimated return to schooling varies because of the widely different time periods covered, each of these studies indicates a significant correlation between schooling level and earnings within twin pairs. When adjustments for measurement error are possible, the resulting estimates typically differ insignificantly from the simpler regression estimates of the return to schooling.

V. Schooling and Income: Instrumental Variables

A. Instrumental Variables Estimates of the Return to Schooling

The evidence from the studies of intra-family differences in education and their correlation with intra-family differences in income strongly support the view that additional schooling is responsible for increases in worker earnings. Despite the consistency of this evidence, none of it represents the equivalent of an ideal experiment. In the past few years, several researchers have attempted to find so called "natural experiments" that would provide the kind of information that an ideal experiment would provide. To do this they have attempted to locate exogenous events that might be expected to alter the schooling decisions of some people, but which would not be expected to independently alter their income.

The basic idea used in the application of this method is straightforward. Suppose that we knew of an event that would increase a group's schooling level. Suppose further that we were certain that this event would not have any direct effect on the group's earnings. We would then estimate the effect of schooling on income in two steps: In the first step we would estimate the effect of the event on the schooling level of the group. In the next step we would measure the

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[9] Both the Australian and Minnesotan data use income imputed from detailed occupational categories as the dependent variable.

effect of the same event on the earnings level of the group. If we find that the income of the group has increased, then we can be sure that education was the cause of the income increase since we were certain that the event had no direct effect on income. The ratio of the income increase caused by the event to the schooling increase caused by the event is a straightforward estimate of the causal effect of an additional year of schooling on income. This instrumental variables (IV) estimator uses the "exogenous" event as the instrumental variable.

To see how this estimation strategy works, consider the recent paper by Angrist and Krueger (1991). Angrist and Krueger note that there is a relationship between the quarter in which an individual is born and the mean level of schooling that the individual attains. Angrist and Krueger argue that compulsory schooling laws are a natural explanation for why individuals born in the first quarter of the year attain less schooling than individuals born later in the year. They observe that school districts typically require that students turn age six by January 1st of the year they enter school. Thus, students born early in the (calendar) year enter school at an older age. Since compulsory schooling laws permit students to drop out as soon as they attain age 16, students born early in the year may drop out of school with fewer years of school completed than those born later in the year. Quarter of birth is a suitable instrumental variable so long as we assume that any difference in the wages of those born in different quarters is a result only of the differences in their schooling.

Angrist and Krueger find that workers born in the first quarter of the year typically average about one-tenth of a year less schooling than workers that are born in the other three quarters of the year. These same workers also generally earn about one percent less per week than other workers. The accident of being born in the first quarter of the year is, therefore, associated with a lower schooling level and a lower earnings level. The implied return to schooling is about 10% per additional year of education attained.

Table 3 contains a summary of the results of several studies that have used the instrumental variables approach to measure the effect of a year of schooling on income. As Table 3 indicates, there have been various applications of this method. Table 3 also indicates that all of these studies have found significant effects of schooling on earnings.

In two studies that use similar instruments, Kane and Rouse (1993) use the distance that a high school student lives from the nearest two- and four-year colleges and Card (1993) uses whether an individual grew up near an accredited four-year college as instruments. Kane and Rouse's regression estimate of the return to schooling is about 8%; on the other hand, their instrumental variables estimate suggests a return of about 9%. Similarly, Card's instrumental variables estimate of the return to schooling is about 10%, an increase from the ordinary regression estimate of 7.3%. Finally, Butcher and Case (1994) have found that the presence of sisters in a family tends to depress the schooling and earnings of women born into these same families. Although one can only speculate about the reasons why the presence of sisters results in lower schooling levels for women, their implied (instrumental variables) estimate of the effect of a year of schooling on the earnings of women is 19%.

All of these estimates indicate that the instrumental variables estimate of the return to schooling is at least as large as that implied by conventional procedures. What might explain these results? These instrumental variables estimates of the return to school may simply reflect the fact that if one views schooling as an investment, then those who undertake the investment must expect to receive a positive net return on their investment (Becker (1967)). Individuals will stay in school until the marginal benefit of the additional schooling equals the marginal discount rate (which may be a function of factors such as the cost of funds). As a result, the group of individuals with lower levels of schooling will be composed of individuals for whom the marginal benefit was low (e.g., individuals with low ability) or for whom the marginal discount rate was high (e.g., individuals from disadvantaged families). Now consider the events (instruments) that have been employed. Compulsory schooling laws will only have an effect on the education level of those who would have

Table 3

Summary of the Estimated Effect of an Additional Year of Schooling on Wages from "Natural Experiments"

Study	Source of "Natural Experiment"	Estimated Return to Schooling	
		OLS	IV
Angrist and Krueger (1991)	Compulsory Schooling Laws	6.3% (0.0)	8.1%[1] (1.1)
Butcher and Case (1994)	Sibling Sex Composition	9.1% (0.8)	18.5% (1.1)
Kane and Rouse (1993)	Proximity to Nearest College	8.0% (0.5)	9.1% (3.3)
Card (1993)	Presence of a Nearby College	7.3% (0.4)	9.7% (0.5)
Behrman, Rosenzweig, and Taubman (1994)[2]	Birth weight	4.1% (0.4)	4.0% (0.5)

Notes: Estimated standard errors are in parentheses.

[1] This IV estimate differs from that in the text because it is for a more recent cohort and includes other covariates.

[2] A within-twin estimate of the return to schooling using both identical and fraternal twins. The OLS estimate in the table is for identical twins; the coefficient estimate for fraternal twins is 4.3% with a standard error of 0.4.

otherwise dropped-out of school. Similarly, the presence of a nearby college will have its largest effect on the schooling of those for whom transportation costs could prove prohibitive. Both such "exogenous" events are likely to have a disproportionate affect on the schooling of individuals with high marginal discount rates, particularly those from disadvantaged families.[10] Thus, the instrumental variables estimate of the return to schooling will reflect the marginal benefit of schooling for a group with high marginal discount rates, which could well exceed the average return in the population estimated using OLS.[11]

Of course, the extent to which these estimates are credible depends on your willingness to believe that the event used to identify the effect of schooling on income has no direct effect on income. Different observers will have different opinions about this issue, and may even disagree about each example. Taken together, however, they consistently provide evidence that schooling is a causal determinant of earnings.[12]

B. Using Instrumental Variables to Evaluate Twins Studies

A recent paper by Behrman, Rosenzweig, and Taubman (1994) uses the instrumental variables approach to assess the validity of twins studies. Skeptics of twins studies often ask, "If identical twins are so identical, why did one twin receive more schooling?" The concern is that if identical twins do differ in their abilities, then the within-twin estimate of the return to schooling will

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[10] The mechanism by which the Butcher and Case instrument would disproportionately affect the disadvantaged is unclear.

[11] This explanation is developed in Card (1995) and Lang (1993).

[12] One criticism that has been raised about a few of the papers using instrumental variables is that the event used as the "natural experiment" is not highly enough correlated with schooling to produce an estimate of the return to schooling that is less biased than the OLS estimate (Bound, Jaeger, and Baker (1995)). While this is potentially an important problem, the events used in all of the studies cited above are correlated enough with schooling that they probably do reduce the bias from using OLS. (See, in particular, Angrist and Krueger (1995)).

be biased upward by ability bias (Neumark (1994)). Unfortunately, because identical twins are generally raised in identical family environments it is nearly impossible to assess the importance of this critique.

Behrman, Rosenzweig, and Taubman have assembled data on twins based on the Minnesota Twins Registry that allows them to attempt to assess the extent to which the within-twin estimate of the return to schooling is upward biased.[13] Since the registry records the twins' birth weights, the authors use birth weight as the exogenous event that determines schooling, but does not influence later earnings. An infant's birth weight is affected by his environment in the womb and, after the egg splits, identical twins are exposed to different environments. They argue that birth weight has also been shown to affect a child's early mental and physical development which affects schooling but not later earnings. As shown in Table 3, Behrman, Rosenzweig, and Taubman estimate a return of about 4%, whether or not they use birth weight as an instrumental variable. The estimate would rise to about 5.7% if corrected for measurement error.[14] Thus, they find no evidence that the within-twin estimate of the return to schooling is upward biased.

VI. Ethnic and Socio-Economic Differences in the Economic Value of Schooling

A second argument by critics of educational programs aimed at low-achieving students is that such programs will not reduce skill differences. These critics argue that while educational programs may raise the average skill level, they will not reduce the disparity of skills because the

[13] The registry contains the birth-records on all twins born in Minnesota from 1936-1955 (approximately 10,400 pairs) with additional family background and individual characteristics information on about 8,400 surviving intact pairs. These data have been recently supplemented with survey information on occupation, education, and martial and fertility histories.

[14] The estimate of the return to schooling is from Table A2; the estimate that the within-twin return to schooling is attenuated by 30% is from Table 3. We also note that Behrman, Rosenzweig, and Taubman do not have actual wages. Rather, they use the average income of the respondent's occupation as their measure of income.

bright students will benefit more from the schooling than the below-average students. Thus, they argue, the "interaction" between education and student characteristics leads to a widening of the skill, and therefore income, distribution.

This assertion has important implications for education policy. According to economic theory, policy makers concerned about efficiency should focus on educational expenditures that have the greatest net benefits for society. More precisely, society should allocate educational resources until the net (marginal) benefit of the last dollar spent on each program is equalized. An implication of this principle is that if high ability students benefit more from educational expenditures than do low ability students, then governments should construct educational policy that emphasizes gifted programs.[15] In the case of the United States, there may be a case for the government to redistribute education dollars away from compensatory education and towards "gifted and talented" programs until the value of the last dollar spent on gifted programs equals the value of the last dollar spent on special or compensatory education programs.

While the economic principle is fairly clear, it rests on the assumption that brighter and more advantaged students benefit more from schooling than their lower achieving and more disadvantaged classmates. In this section we test the assertion that bright and advantaged students benefit most from schooling by examining the value of education in the labor market for different groups of individuals.[16]

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[15] Of course, even if brighter students do benefit the most from schooling, distributional concerns may lead policy makers to emphasize compensatory education programs over gifted programs.

[16] Earlier estimates of the returns to schooling by ability group and social class by Wolfle and Smith (1956), Weisbrod and Karpoff (1968), Hause (1972), Hauser (1973), Taubman and Wales (1973), Jencks, et. al. (1979) produced inconclusive results. This no doubt reflects, in part, the greater demands on the data required by attempts to stratify by measures of ability or family background.

A. Racial and Ethnic Differences in The Return to Schooling

We begin by comparing the return to education across racial and ethnic groups. Figure 5 graphs the economic value of an additional year of schooling by race and ethnicity, separately for women and men, using the 1990 United States Census.[17] The income measure is yearly earnings. The returns to schooling are based on separate regressions by race and ethnic group.[18]

As Figure 5 indicates, there is remarkably little variability in the estimates of the return to schooling by race or sex group. For example, white females earn an additional 13% per year of schooling compared to African-American females who earn a return of 13.3%. Native American women benefit the most from schooling in the labor market. For men, there is even less variation in the return to schooling by race and ethnicity. White, Hispanic, African-American, and Native American males earn between 10.1% and 10.8% more for each additional year of schooling. The exception are Asian/Pacific males who earn an additional 13% per year of additional schooling. Overall, however, these differences are too small to be economically meaningful, particularly since we have not accounted for other potentially important factors, such as discrimination in the labor market.[19]

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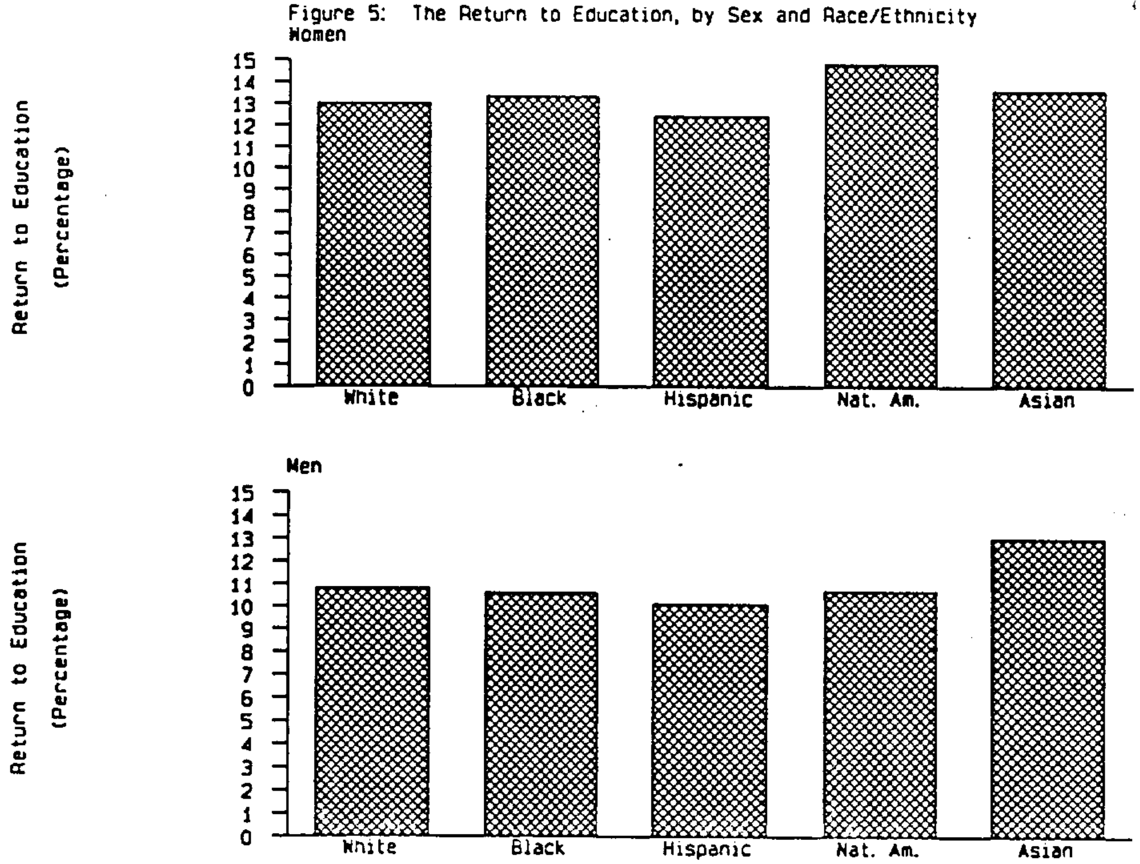
[17] The data in Figure 5 are from the 5% sample of the U.S. Census. We included individuals aged 18-65 who were born in the United States, worked at least one week in the previous year, and earned at least one-half of the minimum wage.

[18] We defined "Hispanics" as all those who identified their ethnicity as "Hispanic"; "Native American" includes Eskimos and Aleuts. The regressions controlled for a quadratic in experience, whether the individual was ever-married, and eight division dummies, and were weighted using the census weight.

[19] We find greater variation in the returns to schooling across the racial and ethnic groups if we use a measure of weekly earnings rather than annual earnings. The difference is accounted for by the fact that for minority groups the association between schooling and weeks worked is stronger than for Whites. Whether this means that schooling leads to more stable jobs (so that the number of weeks worked is exogenous) or that schooling changes individuals' labor supply decisions (so that the number of weeks worked in endogenous) is an empirical question. Ashenfelter and Ham (1979) develop an empirical test to assess the relative importance of these two hypotheses.

Figure 5: The Return to Education, by Sex and Race/Ethnicity



B. The Value of Schooling by Family Background and Measured Ability

The data from the *National Longitudinal Survey of Youth* (NLSY) permit us to examine the value of schooling by socio-economic status and measured ability. The NLSY began surveying 12,686 individuals, aged 14-22, from across the nation in 1979. These same individuals have been reinterviewed every year since then. The NLSY data are unique because they have a rich set of variables from which to construct measures of socio-economic status and measured ability. In the base year, individuals were asked about their parents' educational attainment, income, occupation, and about amenities in the home. Since then, the survey has collected data on each individual's marital status, fertility, educational attainment, and labor market outcomes.[20]

In addition, in 1980 most survey participants were administered the ASVAB (Armed Services Vocational Aptitude Battery), a basic skills test, from which it is possible to construct an Armed Forces Qualification Test (AFQT) score. Herrnstein and Murray (1994) argue that the AFQT has many of the properties of an IQ test; the scores do not just reflect specific knowledge that has been learned in school, rather they reflect more general factors of "intelligence." Neal and Johnson (1996) argue the contrary, that AFQT scores increase with years of schooling and therefore are not a good measure of IQ. Others, such as Rodgers and Spriggs (1996), argue that the AFQT is a racially biased test. While researchers disagree about the determinants of AFQT scores, most would agree that they reflect <u>some</u> information about the skills that individuals possess at the time of the test.

We estimate the return to schooling by family background and ability group by regressing the logarithm of the hourly wage on years of schooling, parents' education or AFQT test score interacted with years of schooling, and other regressors. An estimate of how the return to schooling varies by family background or measured ability is obtained from the coefficient on the

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[20] The Data Appendix describes how we construct our NLSY sample.

years of schooling interacted with either the parents' education or the AFQT test score.[21]

The top panel of Table 4 shows the return to education by the parents' average education level. We report on the value for four levels of parental schooling: an average level less than 12 years (i.e., no high school diploma), an average level equal to a high school diploma, an average level between 13 to 15 years of college (i.e., some college, but no bachelor's degree), and an average level of at least 16 years of schooling (i.e., at least a bachelor's degree). The graph suggests a higher economic value to schooling for individuals who come from low socio-economic backgrounds, although the differences are slight. Those whose parents have not attended college have a return of 5-7%. On the other hand, those whose parents have attended college earn a return of about 5%. While these differences are statistically indistinguishable, if we were to take them at face value we would conclude that those students whose parents have lower levels of schooling actually benefit slightly more from schooling than those from more advantaged backgrounds.

We consider whether "brighter" students benefit more from additional schooling than "low achieving" students by using the AFQT score as a measure of achievement or "ability." The return to schooling by the AFQT quartile of the individual is displayed in the bottom panel of Table 4. We find that the return to schooling is unrelated to AFQT Quartile.[22] Those with test scores in the bottom two quartiles receive a return on their education of about 5-7% compared to those with test scores in the top quartiles who have a return of 5.3%. Figure 6 graphs the return to schooling by the AFQT decile of the individual. As before, it is apparent that the return to schooling is essentially unrelated to ability as measured by test scores.

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[21] The Technical Appendix derives our specification.

[22] Blackburn and Neumark (1993) find that those with higher AFQT scores have a higher return to schooling. However, they do not adjust their AFQT scores for the education level of the individual at the time of the test as we do (see the Data Appendix).

Table 4

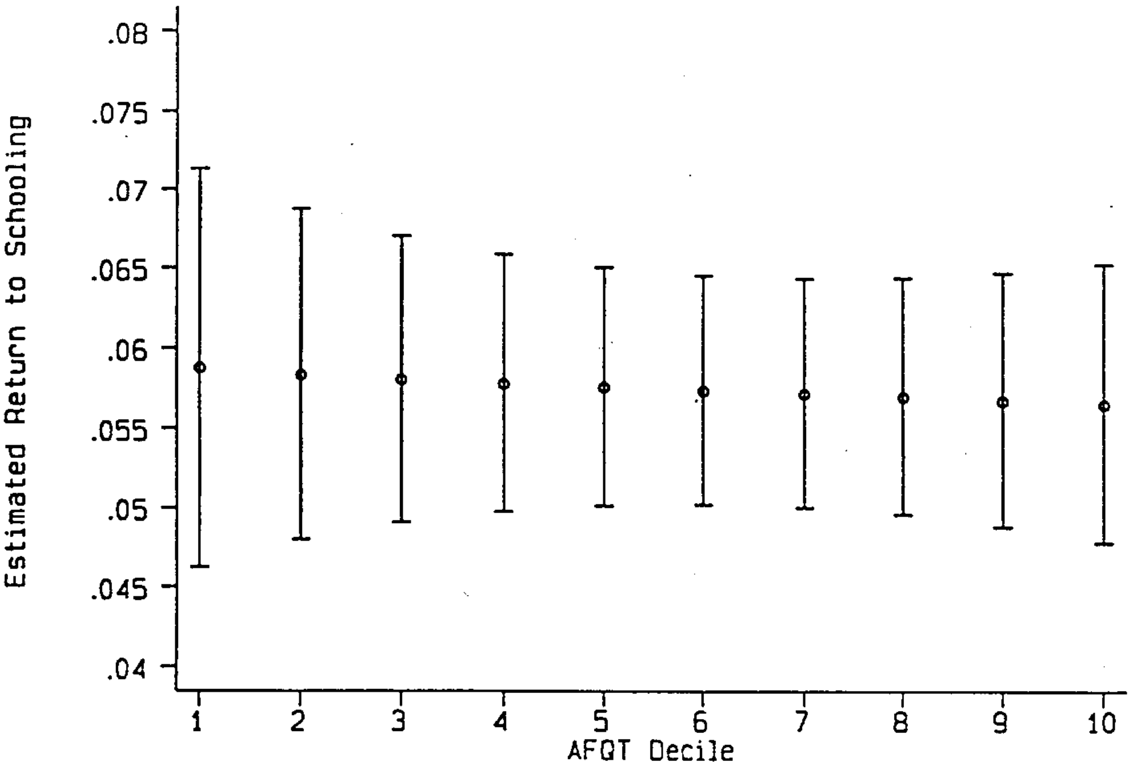
The Return to Education by Parents' Education Level and AFQT Quartile

	Average of Parents' Education Level			
	Less than High School	High School Graduate	Some College	College Graduate
Return to Education	6.7% (0.5)	4.8% (0.6)	5.6% (0.9)	4.9% (0.7)
	AFQT Quartile			
	First	Second	Third	Fourth
Return to Education	5.1% (0.7)	6.8% (0.8)	5.3% (0.6)	5.3% (0.6)

Notes: The dependent variable is log hourly wages. Estimated standard errors are in parentheses. See Appendix Tables 1 and 2 for the actual regression coefficients and other regressors.

Source: Authors' calculations using the NLSY.

Figure 6: Return to Schooling by AFQT Decile
(Point Estimate and Confidence Interval)



C. The Value of Schooling by Family Background Using Siblings

Given the controversy regarding the validity of the AFQT as an accurate measure of "innate ability," perhaps a more convincing way to address the issue of innate ability is to analyze returns to schooling using intra-family variation in education and income. If the value of schooling increases with family background or innate ability, then we should observe higher estimated returns to schooling for siblings and twins with higher socio-economic backgrounds or higher levels of ability.

Altonji and Dunn (1996) analyze the NLS and PSID to estimate the return to schooling by IQ and family background. They do so by estimating first-differenced equations that include an interaction between the difference in the siblings' schooling levels and the measure of ability or family background. The coefficient on the interaction term indicates the extent to which the return to schooling varies by measured ability. A summary of their estimated interaction terms are presented in Table 5.

For men, Altonji and Dunn estimate that a one standard deviation increase in IQ increases the return to schooling by 0.82 percentage points.[23] However, the estimate is not statistically significant. A one year increase in parental education increases the estimated return between 0.09 and 0.81 percentage points, and three out of four of the estimates are significantly significant. For women, however, the results are much less consistent as three out of five of them are negative (and insignificant). Overall, these results provide little consistent evidence that more advantaged individuals enjoy a higher return to schooling. In addition, because siblings do not necessarily have identical genetic endowments, these estimates may be upward biased.

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[23] The estimates of the overall return to schooling are in Table 1.

Table 5

The Within-Sibling Return to Education by IQ and Family Background

Data	Measure of Ability/ Family Background	Estimated Additional Return to Schooling
	Brothers	
NLS	IQ	0.82%[1] (0.93)
NLS	Father's Education	0.51%[2] (0.20)
NLS	Mother's Education	0.81%[2] (0.28)
PSID	Father's Education	0.09%[2] (0.12)
PSID	Mother's Education	0.33%[2] (0.15)
	Sisters	
NLS	IQ	1.46%[1] (0.74)
NLS	Father's Education	-0.04%[2] (0.17)
NLS	Mother's Education	0.58%[2] (0.21)
PSID	Father's Education	-0.11%[2] (0.13)
PSID	Mother's Education	-0.17%[2] (0.18)

Notes: The dependent variable is log hourly wage. Estimated standard errors are in parentheses.
[1] The coefficient is the percentage point change in the return to schooling for a one standard deviation increase in the IQ score.

[2] The coefficient is the percentage point change in the return to schooling for a one year increase in father's or mother's education.

Source Altonji and Dunn (1996).

D. The Value of Schooling by Family Background Using Identical Twins

In Ashenfelter and Rouse (1998) we report analyses of the extent to which the within-family return to schooling varies by family background among individuals with identical genetic endowments using a sample of identical twins. We do so by interacting measures of family background with the difference in the twins' schooling levels, as did Altonji and Dunn. Panels A and B in Table 6 show the value of an additional year of schooling by measures of the family backgrounds of the twins. In panel A, we measure family background as the average of the parents' years of schooling. In panel B, we construct an index of family background using parental education, number of siblings, and parents' occupations. Because the number of individuals upon which the analysis is based is much smaller than in the NLSY, we use only three levels of family background.

The results in panel A suggest slight variation in the economic value of additional schooling. Those whose parents have an average level of schooling that is less than a high school diploma earn approximately 6.2% more for each additional year of schooling, compared to a return of 14.4% for those whose parents have a high school diploma (and no college), and 9.8% for those whose parents attended college. However, these differences are not statistically significant. The results in panel B tell a similar story. In fact, one could conclude that individuals from families in the middle (not the upper end) of the socio-economic distribution receive the highest return to schooling.

VII. Conclusion

Herrnstein and Murray (1994) write, "In short, the school is not a promising place to try to raise intelligence or to reduce intellectual differences...." (p. 414) The evidence presented in this essay shows that, to the contrary, the school is a promising place to increase the skills and incomes of individuals. As a result, educational policies have the potential to decrease existing,

Table 6

The Within-Twin Return to Education by Family Background (Identical Twins)

	Average of Parents' Education Level		
	Less than High School	High School Graduate	At Least Some College
Return to Education	6.2%	14.4%	9.8%
	(3.4)	(3.5)	(4.4)
	Family Background Index[1]		
	Low	Medium	High
Return to Education	6.9%	16.3%	6.1%
	(3.2)	(3.7)	(4.3)

Notes: The dependent variable is log hourly wages. Estimated standard errors are in parentheses. These regressions are estimated by instrumental variables to allow for measurement error.

[1] The "Family Background Index" is a weighted average of parents' education and occupations, and number of siblings. "Low", "Medium," and "High" family indices are the bottom, middle, and top thirds of the index distribution.

Source: Ashenfelter and Rouse (1995).

and growing, inequalities in income.

Herrnstein and Murray also qualify their statement, "... given the constraints on school budgets and the state of educational science." Again, we disagree. Discussions about policy are discussions about possibly changing the constraints. A lack of resources is one problem that has plagued the attempts of public-sector training programs to significantly increase the incomes of participants (LaLonde (1995)). If we really want to make educational programs effective, we must become much more serious about investing in them. Similarly, there is a great deal more to be learned about the role of education in the determination of income. For example, we know relatively little about how the quality of education determines earnings. This is an area where the experimental method can be used extensively to study the role of class size and other educational innovations on learning.

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Technical Appendix

To derive our econometric framework, write a standard log wage equation as,

$$y_{1i} = F_i + bS_{1i} + dX_i + \epsilon_{1i} \tag{1}$$

and

$$y_{2i} = F_i + bS_{2i} + dX_i + \epsilon_{2i} \tag{2}$$

where y_{1i} and y_{2i} are the logarithms of the wage rates of the sons and fathers (or any other two family members), S_{1i} and S_{2i} are the schooling levels of the sons and fathers (or, more generally, all attributes that vary within families), X_i are other observable determinants of wages that vary across families, but not within families (such as race), and ϵ_{1i} and ϵ_{2i} are unobservable individual components. F_i is assumed to be either an observed family or individual component (in the cross-sectional analysis) or an unobserved family or genetic component (in the within-family analysis) that is correlated with observed schooling levels. As a result, if either equation (1) or (2) is estimated by OLS without controlling for family background, the estimate of the coefficient, b, will reflect not only the casual effect of schooling on wages, but the effect of family background (or ability) as well. In the cross-section analysis, one can simply control for family background or "ability" using measures of parents' education or test scores. In the sibling analysis, one can difference equations (1) and (2) to eliminate the family effect, obtaining the (unbiased) within-family (or fixed-effects) estimator,

$$y_{2i} - y_{1i} = b[(S_{2i} - S_{1i})] + \epsilon_{2i} - \epsilon_{1i} \; . \tag{3}$$

In order to test whether the returns to schooling vary by family background, one can estimate an equation with an interaction term between the family members' schooling difference and their family background. The estimating equation is obtained by assuming that the return to schooling, b_i, varies by family and is a function of the family's unobserved "ability," A_i,

$$b_i = b_0 + b_1 A_i \; . \tag{4}$$

The parameter, b_1, reflects the extent to which the return to schooling varies by the "ability" or "learning environment" across families. If some families have higher levels of innate "ability" or more enriching learning environments for their children, and if this background allows the children to benefit more from schooling, then b_1 should be positive. If we permit family background to influence the family effect we have,

$$A_i = \gamma_2 F_i \tag{5}$$

where F_i represents measures such as parents' education or measured ability. The corresponding reduced-form and fixed-effects equations are,

$$\begin{aligned} y_{1i} &= b_0 S_{1i} + \gamma_2 F_i + b_1 \gamma_2 F_i S_{1i} + dX_i + \epsilon_{1i'} \\ y_{2i} &= b_0 S_{2i} + \gamma_2 F_i + b_1 \gamma_2 F_i S_{2i} + dX_i + \epsilon_{2i'} \end{aligned} \tag{6}$$

and,

$$y_{2i} - y_{1i} = b_0[S_{2i} - S_{1i}] + b_1 \gamma_2 F_i (S_{2i} - S_{1i}) + \epsilon_{2i'} - \epsilon_{1i'} \; . \tag{7}$$

Data Appendix: The National Longitudinal Survey of Youth (NLSY)

The NLSY data are from the 1993 wave. In constructing our sample we drop members of the military subsample, the self-employed, those missing information on education in 1993, enrolled in school in 1993, and earning less than two dollars per hour. We use an average of the hourly wages in 1993 and 1992 if both are available, and one if only one is available. We drop those with no valid wage. Wages are converted to 1994 dollars using the implicit price deflator for personal consumption expenditures. The tenure variable is the number of weeks worked at the first or second job. The Armed Forces Qualification Test (AFQT) score is computed as a linear combination of the word knowledge, arithmetic reasoning, paragraph comprehension, and mathematics knowledge subtests of the Armed Services Vocational Aptitude Battery (ASVAB).

In order to test whether the return to schooling varies by the AFQT of the individual, we estimate a specification based on equation (6) in the Technical Appendix. That is, we include total completed schooling S_{Ti}, an unobservable family (or ability) component, F_i, and an interaction between the two:

$$y_i = \delta F_i + \beta S_{Ti} + \gamma S_{Ti} F_i + \epsilon_i \ . \qquad (8)$$

The problem in the NLSY is that the AFQT was administered when the individuals were different ages and had completed differing years of education. To incorporate this fact into our framework, we assume that the AFQT score, T_i, is a function of F_i, and schooling at the time of the test, S_{Bi}:

$$T_i = F_i + bS_{Bi} + e_i \qquad (9)$$

which can be rewritten as,

$$F_i = T_i - bS_{Bi} - e_i \qquad (10)$$

Substituting equation (10) into equation (8) results in our basic specification,

$$y_i = \beta S_{Ti} - (\delta b) S_{Bi} + \gamma S_{Ti} T_i - (\gamma b) S_{Ti} S_{Bi} + \delta T_i - v_i \qquad (11)$$

where the error term $u_i = \delta e_i + \gamma S_i e_i - \epsilon_i$. Thus, to control for schooling at the time of the test, we include the level effect of this previous schooling and an interaction of the previous schooling with the total level of schooling in 1993. We also include a quartic in age.

The AFQT quartiles are calculated using the weighted distribution of scores (using the ASVAB weight). The distribution across the AFQT quartiles is:

	AFQT Quartile			
	First	Second	Third	Fourth
Percentage of Sample	42.1	24.1	18.3	15.4

The distribution is not even because of the NLSY oversamples (as part of the supplementary sample) the disadvantaged.

We average the parents' education if both are available and use only one if only one is available. We also include a dummy variable indicating that both parents' education levels are missing.

	Average of Parents' Education Levels				
	Less than High School	Equal to High School	Some College	At Least College Degree	Missing Both Parents' Education
Percentage of Sample	47.1	29.0	14.3	5.8	3.8

Appendix Table 1

OLS Estimates of the Return to Schooling and by Family Background using the NLSY

	Overall Return to Schooling	Return to Schooling by Parents' Education
Education in 1993	0.057 (0.004)	0.050 (0.006)
Education*Parents' Educ = High School		0.017 (0.007)
Education*Parents' Educ = Some College		-0.001 (0.008)
Education*Parents' Educ = College+		0.006 (0.011)
Parents' Education = High School		-0.166 (0.091)
Parents' Education = Some College		0.133 (0.110)
Parents' Education = College+		-0.0002 (0.164)
Parents' Education (Years) ÷ 10	0.092 (0.026)	
AFQT Score ÷ 10	0.033 (0.003)	0.033 (0.003)
Education in 1980	0.043 (0.006)	0.044 (0.006)
R^2	0.296	0.298

Note: There are 6748 observations. Estimated standard errors are in parentheses. Other regressors included a dummy indicating whether both parents' education levels were missing, a quartic in age in 1979, a dummy variable indicating if the grade in 1980 is missing, a dummy indicating whether the individual was part of the supplementary sample, sex, race, an urban dummy and whether the urban status is missing, three region dummies, and a constant. The regressions were weighted using the 1993 sample weight.

Appendix Table 2

OLS Estimates of the Return to Schooling by AFQT using the NLSY

	Return to Schooling by AFQT Quartile	Return to Schooling by Linear AFQT
Education in 1993	0.022	0.030
	(0.012)	(0.012)
Education*AFQT, 2nd Quartile	0.015	
	(0.010)	
Education*AFQT, 3rd Quartile	-0.001	
	(0.010)	
Education*AFQT, 4th Quartile	-0.004	
	(0.010)	
AFQT, 2nd Quartile	-0.081	
	(0.128)	
AFQT, 3rd Quartile	0.228	
	(0.124)	
AFQT, 4th Quartile	0.339	
	(0.136)	
Education*AFQT ÷ 1000		-0.032
		(0.109)
Parents' Education (Years) ÷ 10	0.077	0.093
	(0.026)	(0.026)
AFQT Score ÷ 10		0.038
		(0.015)
Education in 1980	0.003	0.007
	(0.019)	(0.019)
Education in 1993*Education in 1980	0.003	0.003
	(0.001)	(0.001)
R^2	0.299	0.296

Note: There are 6748 observations. Estimated standard errors are in parentheses. Other regressors included a dummy indicating whether both parents' education levels were missing, a quartic in age in 1979, a dummy variable indicating if the grade in 1980 is missing, a dummy indicating whether the individual was part of the supplementary sample, sex, race, an urban dummy and whether the urban status is missing, three region dummies, and a constant. The regressions were weighted using the 1993 sample weight.