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ABSTRACT

We exploit a natural experiment to estimate the causal impact of parental education on educational outcomes of their children when they are high school seniors. In 1968, the Taiwanese government extended compulsory education from 6 to 9 years and opened over 150 new junior high schools at a differential rate among regions. We form treatment and control groups of women or men who were age 12 or under on the one hand and between the ages of 13 and 25 on the other hand in 1968. Within each region, we exploit variations across cohorts in new junior high school openings to construct an instrument for schooling. We employ this instrument to estimate the causal effects of mother's and father's schooling on their child's college entrance examination test scores in the years 2000-2003, on the probability that the child attended college and on the rank of the college attended. The schooling of each parent does cause their child to experience better educational outcomes. A one-year increase in the schooling of either parent raises the probability that the child attends one of the top six colleges in Taiwan by approximately 10 percent.

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I. Introduction

The positive association between parental education and offspring's educational achievement is well documented in the literature (Haveman and Wolfe 1995; Strauss and Thomas 1995; Solon 1999). This relationship does not, however, imply causality from the former to the latter. In particular, omitted "third variables" may cause both of them to vary in the same direction. For example, Fuchs (1982) argues that persons who are more future oriented (who have a high degree of time preference for the future or who discount the future at a modest rate) attend school for longer periods of time and make larger investments in the educational achievement of their children. Thus, the effect of parental education on this outcome is biased if one fails to control for time preference. The time preference hypothesis is analogous to the hypothesis that the positive effect of schooling on earnings, explored in detail by Mincer (1974) and in hundreds of studies since his seminal work (see Card 1999, 2001 for reviews of these studies), is biased upward by the omission of ability. Behrman and Rosenzweig (2002) present an argument that is even more closely related to ability bias in the earnings-schooling literature. In their model, parents with favorable heritable endowments obtain more schooling for themselves, are more likely to marry each other, and raise children with higher levels of education. In turn these endowments reflect ability in the market to convert hours of work into earnings and childrearing talents in the nonmarket or household sector.

Efforts to distinguish causal effects of parents' schooling on children's schooling from effects due to omitted variables have important policy implications. If there is a causal mechanism, then policies to increase the education of one generation will have spillovers to future generations. These benefits will not, however, be realized in the absence of causality.

In this paper we propose to use an instrumental variable technique that corrects for biases due to omitted third variables to evaluate the effects of a policy initiative that radically altered the school system in Taiwan and led to an increase in the amount of formal schooling acquired by the citizens of that country during a period of very rapid economic growth. In 1968 Taiwan extended compulsory schooling from 6 to 9 years. In the period from that year through 1973, many new junior high schools were opened at a differential rate among counties of the country.[1] We form treatment and control groups of women or men who were age 12 or under on the one hand and between the ages of 13 and 22 or 25 on the other hand in 1968. Within each county, we exploit variations across cohorts in new junior high school openings to construct an instrument for schooling. We employ this instrument to estimate the causal effects of mother's and father's schooling on several educational outcomes pertaining to the children of women and men in the treatment and control groups when they were high school seniors in the years 2000-2003. The outcomes of interest are college entrance examination test scores, the probability of attending college, and the rank of the college attended.

II. Literature Review

Recent economic literature has employed three strategies to investigate whether higher levels of parents' schooling cause their children to realize better educational outcomes. The first approach employs data on identical twins; the second employs data on adoptees; and the third uses instrumental variables. Behrman and Rosenzweig (2002) control for unmeasured third variables by examining differences in years of formal schooling completed by the offspring (cousins) of 424 female and 244 male identical (monozygotic) twins in the U.S. While mother's schooling has a positive and significant effect on children's schooling in the cross section, the within-twin estimate either is insignificant or negative and marginally significant. On the other hand, the coefficient of father's schooling is positive and

[1] There were 21 cities or counties in Taiwan in 1968. Hereafter the term county refers to city or county in Taiwan.

significant in both cases.

While the study by Behrman and Rosenzweig is novel and provocative, several considerations suggest that their findings should not be viewed as definitive. First, it is based on a small sample. Second, differencing between twins exacerbates biases due to measurement error in schooling (Griliches 1979; Bound and Solon 1999; Neumark 1999), although Behrman and Rosenzweig do attempt to adjust for these biases. Third, Bound and Solon (1999) stress that variation in schooling between identical twins may be systematic rather than random. Finally, subsequent work with the same data by Antonovics and Goldberger (2005) indicates that the results are sensitive to the way in which the data are coded.

Plug (2004), Björklund, Lindahl, and Plug (2006), Sacerdote (2007), and de Walque (2009) control for genetic endowment by studying the relationship between parents' and children's schooling in families with adopted children. In general, these studies report positive effects. Some of them are able to control for nonrandom assignment (positive correlations between schooling levels of biological and adoptive parents) by including biological parents' schooling as a regressor. Sample sizes, however, tend to be small. Moreover, one cannot rule out the hypothesis that the observed effects are due to such unobserved factors as time preference.

Our research strategy is directly related to the instrumental variables procedure employed by Chevalier (2004); Black, Devereux, and Salvanes (2005); Oreopoulos, Page, and Stevens (2006); and Carneiro, Meghir, and Parey (2010). The authors of the first three papers employ changes in compulsory schooling laws as the instrument for parents' schooling. Chevalier (2004) employs the increase in the minimum school leaving age from 15 to 16 in England and Wales in 1972 and a similar increase in Scotland in 1975 in a regression discontinuity design. His outcome is the probability that a child aged 16 through 18 in the period from 1994 through 2002 was still in school. His instrumental variables estimates indicate that a one-year increase in the number of years of schooling completed by either parent increases this probability by 4 to 8 percentage points.

Black, Devereux, and Salvanes (2005) capitalize on the staggered adoption of compulsory education from 7 years to 9 years in 545 municipalities in Norway in the period from 1960 through 1972. They find a positive but not statistically significant causal effect of mother's or father's schooling on children's schooling. Among mothers with low education, however, they find a positive and statistically significant effect. They do not include mother's education and father's education in the same regression.

Oreopolous, Page, and Stevens (2006) exploit within states changes in compulsory schooling laws in the United States. Their outcome is grade-for-age among children between the ages of 7 and 15 in the 1960, 1970, and 1980 U.S. censuses. They find that an increase in either parent's education has a causal negative impact on the probability that a child repeats a grade. They are not able to determine whether mother's schooling is more or less important than father's schooling because their specification forces the coefficient of each variable to be the same.

Carneiro, Meghir, and Parey (2010) employ local variation in college tuition costs, unemployment rates, and wages as instruments. The last two variables are proxies for he opportunity cost of attending college. Their outcomes pertain to the children of women in the National Longitudinal Survey of Youth 1979 and include scores on mathematics and reading tests at age 7 or 8 and the incidence of behavioral problems at the same ages. They find significant causal schooling effects on these outcomes in the expected directions. They do not consider the impacts of father's schooling.

Our study differs from the four just discussed in a variety of ways. First, we deal with compulsory school reform in a developing country: Taiwan in 1968. Second, our instrument combines compulsory school reform, from 6 to 9 years in our case, with a measure of the number of new junior high schools in each county available to accommodate the new law. Third, we deal with a variety of outcomes related to post-secondary education. Finally, unlike the three most recent studies, we include mother's schooling and father's schooling in the same regressions and thus obtain estimates of the separate and independent effects of each.

III. 1968 Educational Reform in Taiwan

In 1968, the Taiwan government abolished the junior high school entrance examination and extended compulsory education from six to nine years. Starting at age 6, children were required to attend tuition-free elementary school for 6 years and junior high school for 3 years. Prior to the 1968 education reform, primary school education was nearly universal. However, only about one-half of primary school graduates could succeed in very competitive national entrance examination and continue their secondary education (DGBAS 1983).[2] To accommodate the expected increase in enrollment in junior high school after the reform, the government opened 150 new junior high schools, an increase of almost 50 percent, at the beginning of the 1968-69 school year. This education reform created the largest expansion in junior high school construction and student enrollment in Taiwan's history (see Tsai 2007 and the sources listed in

[2] Prior to the 1968 reform, 5th and 6th grade students whose parents wanted them to attend junior high school were often forced to attend supplementary classes to review the subjects for the entrance examination. For example, they would need to complete considerable amounts of homework each day, comprising of 40-50 mathematical problems, as well as practice in Chinese vocabulary, in preparation for the entrance examination. Most parents were also prepared to pay private institutions specializing in examination preparation to help their children prepare for examination.

Table 1).

The reform was achieved through two three-year plans. The first of these plans, which began in 1968, was mainly aimed at increasing the number of junior high schools so as to accommodate the expected flood of primary school graduates. The second three-year plan, from 1971 to 1973, then focused on improving the quality of the educational inputs. These plans were accompanied by a huge increase in the amount of public resources committed to the education sector, particularly in the first three years.

In 1967-1968, there was an increase of 19.78 percent in the island's total educational expenditure to NT$4,474 million dollars, with high school education accounting for NT$1,171 million dollars of the total. Between 1964 and 1967, the average educational expenditure had accounted for 14.5 percent of all government expenditure and 2.45 percent of the island's GDP. By 1970, these shares had risen to 18.18 percent and 3.21 per cent, respectively (Ministry of Education 1968-1971).

The influx of education resources and the sizable openings of new junior high school during this period increased the number of these schools from 0.3 per thousand children ages 12 through 14 in the academic year 1967-1968 to 0.4 schools per thousand children in that age range in the academic year 1968-1969 (see Table 1 for sources).[3] By 1973, the total number of junior high schools increased from 311 in 1967 to 565 in 1973 (0.5 junior high schools per thousand children 12-14). As a result, the percentage of primary school graduates who entered junior high school increased from 62 percent in 1967 to 75 percent in 1968, eventually achieving 97 percent in 1980 (see Figure 1 in Chou et al. 2010). The percentage of 15-year-olds who completed junior high school also increased from 50 percent in 1969 to 62 percent in 1970, the year when the first cohort of affected students graduated, and climbed to 81 percent in 1976 (see

[3] Hereafter school year t denotes the school year that starts in September of year t and ends in June of year t+1.

Figure 1).

A notable aspect of the school construction program was that its intensity varied across regions of Taiwan. Table 1 contains the number of new junior high schools that opened in 1968 per thousand children between the ages of 12 and 14 in that year in each of the 21 cities or counties of Taiwan. The table also contains the cumulative number of new junior high schools in each of the years 1969 through 1973 per thousand children between the ages of 12 and 14 in that year. In 1968, program intensity varied from 0.02 in Kaohsiung City and Kaohsiung County to 0.53 in Penghu County. By 1973, intensity varied from 0.07 in Changhua County to 0.91 in Penghu County.

Hence, the nine-year compulsory schooling law provides a “natural experiment” to evaluate the impacts of parents' schooling on the educational achievement of their children. In particular, those over the age of 12 on September 1, 1968 when the school year began were unlikely to be affected by school reform and constitute a control group. On the other hand, those 12 years of age and under on September 1, 1968 were very likely to have been affected by school reform and constitute a treatment group. Moreover, the effects of school reform on the number of years of formal schooling completed in the treatment group should be larger the larger is the program intensity measure in county of birth.

IV. Data and Sample

The outcomes of interest in this paper involve children's performance on entrance examinations to higher education, the probability of attending university/college (hereafter termed college), and the rank of the college attended. For senior high school graduates, there are two primary means of access to colleges in Taiwan: (i) applications for admissions; and (ii) assignment to a major at a specific institution based on a candidate’s scores on the Joint College

Entrance Examination (JCEE). The process involved in the former is similar to that involved in admissions to colleges and universities in the U.S. As part of their applications for admission, all applicants are required to take a competency test, which is held in February of the senior year of high school, and then submit their competency test scores to specific colleges to become candidates for the second round of applications.

The competency test consists of five subjects including Chinese, English, Mathematics, Social Sciences, and Natural Sciences. The score in each subject ranges from 1 through 15. The college determines admissions based on several factors including competency test scores, written applications, recommendations, and personal interviews. Students who are rejected or who decide not to apply based on their competency test scores then have a second chance by taking the JCEE held in July after they have graduated from high school.

The JCEE subjects are Chinese, English, Mathematics for engineering and natural sciences (referred to as Mathematics a), Mathematics for humanities and social sciences (referred to as Mathematics b), History, Geography, Physics, Chemistry, and Biology. The total score for each subject ranges between 0 and 100. Prior to holding the examination, each college lists the required subject tests for admission. Students are then assigned to a major at a specific college based upon their examination scores and their preferred major and institution.

Our primary data source is the 2000-2003 College Application files and Joint College Entrance Examination (JCEE) files, compiled by the College Entrance Examination Center at the Ministry of Education (MOE). The MOE data cover all applications for admission to college or university in February and July. The files include information on each student's test scores, whether or not the student gained admission to college, and the name of the college that the student entered. We merge the files just described with birth certificate records maintained by the Ministry of Interior Affairs. These certificates contain the following key information that is relevant for our research: mother's exact date of birth, mother's county of birth, mother's years of formal schooling completed, father's exact date of birth, father's county of birth, father's years of formal schooling completed, child's county of birth, child's gender, and child's birth order.

In Taiwan children must be 6 years old by September 1 of year t to enter the first grade in the academic year that starts on that date. Therefore, we restrict our sample to children born between 1981 and 1985 and eligible to take the JCEE in July in one of the years from 2000 through 2003. To be more specific, we concentrate on four cohorts: those who were 18 on September 1, 2000 (born from September 2, 1981 through September 1, 1982); 18 on September 1, 2001 (born from September 2, 1982 through September 1, 1983); 18 on September 1, 2002 (born from September 2, 1983 through September 1, 1984); and 18 on September 1, 2003 (born from September 2, 1984 through September 1, 1985). This yields 1,423,083 observations. We further limit the sample to children whose mothers were married and between the ages of 22 and 45 when they were born and whose fathers were between the ages of 22 and 50 (N=1,152,483).[4] We select a wider age range for fathers than for mothers because husbands typically are older than their wives. We obtain our final sample for analysis by dropping observations with missing values of parental education. That yields 1,118,879 children, with approximately 280,000 in each of the four cohorts.

The crucial feature of the selection procedure just described is that it results in a sample of 18-year-olds in the years from 2000-2003 whose mothers were between the ages of less than 1 and 22 as of September 1, 1968 and whose fathers were between the ages of less than 1 and 25 in 1968. Mothers or fathers who were less than 12 in 1968 were exposed to the compulsory school reform legislation enacted in that year and form the treatment group, while older mothers and

[4] Births to unmarried women are very rare in Taiwan and account for less than 2 percent of all births in our sample period.

fathers form the control group. Since we are interested in the partial effects of mother's and father's schooling on their child's educational outcomes (the effect of one variable, with the other one held constant), we exclude couples in which the father was between the ages of less than 1 and 25 in 1968, but the mother was not born until after that year. Along the same lines, we exclude couples in which the mother was between less than 1 and 22 in 1968, but the father was older than 25 in that year.

When we merge the final sample of birth certificates of slightly more than 1.1 million 18-year-olds in 2000-2003 with the files containing competency test and JCEE scores based on common person identification numbers on all files, we obtain 286,698 test-takers or 25.62 percent of the full sample. The most important source of the small percentage of matches is that many students did not take the tests because they dropped out of high school or graduated but did not want to attend college. Hence, as explained in the next section, not only do we treat the probability of taking the test as an additional outcome, but we use the estimated equation to correct for the selected nature of the sample of test-takers. Note that among test-takers, only 9 percent gained admission to college based on the February test, making the JCEE the key factor in the determination of this outcome.

V. Empirical Specification

To identify causal effects of mother's schooling and father's schooling on post-secondary school outcomes of their children, we employ the 1968 compulsory school reform legislation to form instruments for parents' schooling. A given parent's date of birth and the county of residence at age 12 years in 1968 jointly determine that individual's exposure to the legislation and the intensity of new junior high school construction that accompanied it. Hence, we form treatment and control groups of women or men who were age 12 or under and between the ages of 13 and 22 or 25 in 1968, respectively. Within each county of residence, we exploit variations across cohorts in total number of new public junior high schools per 1,000 children ages 12-14 in a given year (hereafter termed as program intensity).

Specifically, following Duflo (2000, 2001), Clark and Hsieh (2000) and Chou et al. (2010), we focus on the following three–equation model:

$$E_{ijk}^{m} = \delta^{m}(P_{j_m k_m}^{m} \times T_{i}^{m}) + C_{ik_m}^{m} + R_{ij_m}^{m} + Z^{m} + Y^{m} + \varepsilon_{ijk}^{m} \qquad (1)$$

$$E_{ijk}^{f} = \delta^{f}(P_{j_f k_f}^{f} \times T_{i}^{f}) + C_{ik_f}^{f} + R_{ij_f}^{f} + Z^{f} + Y^{f} + \varepsilon_{ijk}^{f} \qquad (2)$$

$$S_{ijk}^{c} = \theta^{m}E_{ijk}^{m} + \theta^{f}E_{ijk}^{f} + C_{ik_m}^{m} + C_{ik_f}^{f} + R_{ij_m}^{m} + R_{ij_f}^{f} + Z^{m} + Z^{f} + Y^{m} + Y^{f} + X^{c} + \varepsilon_{ijk}^{c}. \qquad (3)$$

In equations (1) and (2), E_{ijk}^{m} and E_{ijk}^{f} are years of schooling of formal schooling completed by mother (i_m) and father (i_f) born in county j={j_m, j_f} and belonging to cohort k={k_m, k_f}. In equation (3), the superscript c denotes that the individual is a child with parent pair i born in county pair j={j_m, j_f} and belonging to cohort pair k={k_m, k_f}; and S_{ijk}^{c} is a test score, the probability of attending college, or the rank of the college attended.

In equation (1), $P_{j_m k_m}^{m} \times T_{i}^{m}$ is the instrument for mother's schooling, and in equation (2), $P_{j_f k_f}^{f} \times T_{i}^{f}$ is the instrument for father's schooling. Either variable is defined as the product of treatment status and program intensity. The former identifies women or men who were between the ages of less than 1 and 12 in 1968. The latter equals the county-specific cumulative number of new junior high schools per thousand children ages 12-14 in the year in which the cohort entered junior high school, as shown in Table 1. To be specific, 12 year olds are assigned the program intensity measure in 1968, 11 year olds are assigned the intensity measure in 1969, 10 year olds are assigned the measure in 1970, 9 year olds are assigned the measure in 1971, 8 year olds are assigned the measure in 1972, and those 7 years old and younger are assigned the measure in 1973. Note that for a given couple, program intensity will have the same value for the husband and the wife only if each member was the same age in 1968 and was born in the same county.

The vectors $C^{m}_{k_m}$ and $C^{f}_{k_f}$ in each equation contain cohort indicators that capture trends in schooling not associated with reform or program intensity (17 cohort indicators for mothers and 20 cohort indicators for fathers).[5] The vectors $R^{m}_{ij_m}$ and $R^{f}_{ij_f}$ contain county indicators that control for cohort-invariant unmeasured factors that vary among counties and may be correlated with schooling and program intensity. The vectors Z^m and Z^f (subscripts suppressed) contain interactions between mother's or father's treatment status and three county-specific variables. They are the junior high school enrollment rate in 1966, the percentage of workers in agriculture in 1967, and the number of junior high schools in 1967 per thousand children ages 12-14 in that year. By including these variables, we control for obvious factors that may be correlated with intensity and schooling (see Chou et al. 2010 for more details).

The vectors Y^m and Y^f contain mother or father's age at birth of the child and interactions between a linear trend for the years 2000-2003 and mother or father's county of birth. These variables are employed to balance the treatment and control groups on as many observable characteristics as possible. The issue here is that the control group parents are older than the treatment group parents. Given the upward trend in schooling, one would expect the former group to have less education than the latter and that the cohort indicators would account for this trend. But the parents in each group had a child who was 18-years-old in the period from 2000 through 2003. Since more educated parents have fewer children and have them at later ages,

[5] Technically, the term vector in the text refers to the product of column vector of variables and a row vector of coefficients. We suppress coefficients associated with all variables except for mother's and father's schooling and the instrument for each of these variables in the equations and in the text.

mean education in the control group actually exceeds mean education in the treatment group both for mothers and for fathers. Combined with the cohort indicators, the members of the Y^m and Y^f vectors account for compositional differences between the two groups.

The vector X^c (subscripts suppressed) in equation (3) contains child characteristics that include a male indicator, a first-child indicator, the interaction between the two indicators just mentioned, 3 indicators for the examination years 2001-2003, and indicators for the child's county of birth. These variables take account of factors that might affect the child's outcomes such as differences in the allocation of resources between sexes and among siblings, trends in the difficulty of the entrance examinations, and regional differences in educational resources.

If equation (3) is obtained by ordinary least squares, the coefficients of mother's and father's schooling are likely to be inconsistent estimates of the true parameters of these variables (θ^m and θ^f, respectively) since E^m_{ijk} and E^f_{ijk} may be correlated with the disturbance term in the equation $\left(\varepsilon^c_{ijk}\right)$. For example, parents who are more future oriented or who have higher levels of ability are more likely to obtain more schooling for themselves and to raise children who obtain higher scores on college entrance examinations. This suggests that the disturbance term in equation (3) is correlated with the corresponding disturbance terms in equations (1) and (2). Hence, we employ the interaction between mother's treatment status and program intensity as an instrument for her schooling and the interaction between father's treatment status and program intensity as an instrument for his schooling in estimating equation (3). The identifying assumptions are that, conditional on covariates, the instruments just described are uncorrelated with the disturbance terms in equations (1)-(3).

We only observe test scores and the outcomes of college applications for test-takers. Since these youths may be a non-random sample, we also estimate the probability of taking one or both of the college entrance examinations $\left(W^c_{ijk}\right)$ as a function of all the right-hand side variables in equation (3) and the high-school graduation rate (G). The latter variable varies by child's county of birth and examination year and serves as the exclusion restriction since it is omitted from equation (3):

$$W_{ijk}^{c} = \theta^{m} E_{ijk}^{m} + \theta^{f} E_{ijk}^{f} + C_{ik_m}^{m} + C_{ik_f}^{f} + R_{ij_m}^{m} + R_{ij_f}^{f} + X^{c} + Z^{f} + Z^{m} + G + \varepsilon_{ijk}^{cw} \qquad (4)$$

In order to handle both non-random selection into the sample of test-takers and the endogeneity of parental education, we estimate equations (1)-(4) using Roodman's (2007, 2009) conditional recursive mixed-process estimator. This assumes that the error terms in those equations ($\varepsilon^{m}, \varepsilon^{f}, \varepsilon^{c}, \varepsilon^{cw}$) are jointly normally distributed. Estimation is by limited-information maximum likelihood, with the instruments for mother's and father's schooling described above employed to obtain equations (3) and (4). In next section, the model that consists of equations (1)-(4) is labeled as the "Instrumental Variables (IV) Model." For comparative purposes, we also estimate a model that only includes equations (3) and (4) and that ignores the endogeneity of parents' schooling. We term it the "Ordinary Least Squares (OLS) Model." All standard errors are adjusted for clustering by mother's and father's county of birth pair.[6]

Note that equations (1)-(4) constitute a recursive system with correlated errors rather than a simultaneous equations system with reverse causality. In particular, we assume that a given spouse ignores the likelihood of finding a more-educated mate by attending school for a longer period of time. In addition, we assume that spouses ignore the impact of their schooling on the educational outcomes of their children. If the former assumption is not correct, the amount of schooling completed by one spouse would depend on the program intensity measure of the other spouse and on that spouse's cohort and county of birth. If the latter assumption is not correct, the child's characteristics in the X^{c} vector as well as both program intensity measures would appear

[6] Since there are 21 counties, the maximum number of clusters is $21^2 = 441$. The standard errors are, however, similar if they are adjusted for clustering by either mother's county of birth or father's county of birth.

in equations (1) and (2).

Given the amount of uncertainty that exists when an individual or their parents make schooling decisions, we think our assumptions are reasonable. Moreover, the mother's intensity measure, for example, is a proxy for one component of the cost of her schooling. On the other hand, the intensity measure of her husband is a proxy for one component of the benefit to her schooling. We lack instruments for other benefits of that schooling, the most important of which is higher earnings. Given that, it is reasonable to include a single instrument in each schooling equation.

We do take account of some aspects of selective mating--the tendency for individuals with similar characteristics to marry--by allowing the disturbance terms in equations (1) and (2) to be correlated. We also include cohort, county of birth, and the Z and Y vectors for each spouse in equations (3) and (4). That means that variations in schooling in those two equations are due solely to variations in program intensity. Finally, our procedure avoids the extremely high degree of multicollinearity that results when both instruments are used to predict mother's schooling and father's schooling.

VI. Results

Means and standard deviations of the dependent variables are shown in panel A of Table 2. With regard to the test scores, students who take the competency test in February must take examinations in all five subjects. Hence a total score is reported as well as a score on each test. That is not the case for the JCEE. As explained in Section IV, prior to the date on which the JCEE is given, each college lists the required subject tests required for admission with a specific major. That is, students must declare a major as part of their application for admission. As a result of this process, the sample sizes for specific JCEE tests vary. For example, approximately

46 percent of the students take JCEE tests in Mathematics a, Chemistry and Physics because they want to major in one of those three subjects. Unlike in the U.S., public colleges are ranked higher than private colleges. Therefore, we employ the probability of being admitted to a public college and the probability of being admitted to one of the top 6 public colleges as well as the probability of being admitted to college as outcomes in addition to the test scores.

Panel B of Table 2 contains means and standard deviations of mother's schooling and father's schooling for the entire sample and for the sample of test-takers. In the former sample, fathers obtain approximately one more year of schooling than mothers (9.7 versus 8.8). Not surprisingly, both levels of schooling are larger in the latter sample (11.5 for fathers and 10.5 for mothers), but fathers still obtain one more year of schooling in the sample of test-takers.

Panel A of Table 3 contains estimates of the effects of educational reform on mother's and father's years of formal schooling completed from the specification given by equations (1) and (2). The effects of education reform are given by the coefficients of the interaction between program intensity and the dichotomous indicator for treatment status.[7] These coefficients are positive and significant at the 1 percent level for both mother's and father's years of schooling. The F-ratios associated with an approximate test for weak instruments are 9.55 for mother's program intensity and 8.01 for father's program intensity.[8] The former is approximately equal to the critical value of 10 used to assess whether instruments are weak (for example, Staiger and Stock 1997; Cameron and Trivedi 2005). The latter is somewhat below that value but exceeds the

[7] These coefficients are taken from the full IV model given by equations (1)-(4). In particular, they take account of the correlation between the disturbance terms in the equations for mother's and father's schooling. In fact, there are 18 estimates of this system since there are 18 dependent variables for test-takers in panel A of Table 2. For each program intensity variable, the modal coefficient, and its T-ratio are reported. There is very little variation in these coefficients and T-ration. For mother's program intensity, the coefficients range from 0.607 to 0.615, and the T-ratios range from 2.99 to 3.11. For father's program intensity, the coefficients range from 0.635 to 0.646, and the T-ratios range from 2.83 to 2.89.

[8] We term this an approximate test because it has been developed in the context of Roodman's conditional recursive mixed process estimator.

value of 5, which Cameron and Trivedi (2005) propose as a less strict rule of thumb.

The estimates presented in panel A of Table 3 suggest that the construction of one additional school per 1,000 children ages 12-14 led to an increase in educational attainment of 0.61 years for females and 0.64 years for males. For both females and males in the treatment group, the cumulative number of new junior high school openings per thousand children ages 12-14 has an average of 0.2. Thus, the program led to an increase of 0.12 years of completed schooling for females and led to an increase of 0.13 years of completed schooling for males.[9] Put differently, the legislation induced approximately 10 percent of individuals in the treatment group to obtain an additional year of formal schooling regardless of gender.

Panel B of Table 3 contains estimates of the effects of parents' schooling on the probability that their child took the competency or JCEE or both tests. Both the OLS and IV estimates indicate that a one-year increase in the schooling level of either parent raises this probability by 2 percentage points or by approximately 8 percent relative to the mean probability of 0.256. While the IV coefficients have much larger standard errors than the OLS coefficients, the former still are significant at the 1 percent level. These results constitute our first piece of evidence that parents' schooling causes a favorable educational outcome for their children since the probability of taking the college entrance examination test is highly correlated with the probability of completing high school. Moreover, an increase in the education of one parent, with the education of the other parent held constant, improves this outcome. Obviously, the estimates in panel B of Table 3 do not shed light on the issue of which education variable is more important.

In Table 4, scores on the February competency test are treated as outcomes. For both

[9] These increases are smaller than the increases of 0.25 and 0.20 for females and males, respectively, reported by Chou et al. (2010). But they consider women who gave birth during the period from 1978 through 1999 and their husbands, while we limit our sample to women who gave birth from 1981 through 1985 and their husbands.

mother's schooling and father's schooling, the six OLS coefficients are positive and highly significant. A one-year increase in the amount of schooling obtained by either parent raises the total score on the examination by approximately 0.3 points or by 0.6 percent relative to the mean total score of approximately 48. While this may appear to be a small effect, the highly competitive nature of the college entrance selection process in Taiwan means that a difference of less than 1 point between two applications can be the deciding factor between acceptance and rejection (see below). Most of the IV coefficients are smaller than the corresponding OLS coefficients. When the total score is the outcome, only the coefficient of mother's schooling is significant. The effect of a one-year increase in that schooling variable now amounts to 0.2 points. Based on the Wu-Hausman test, the OLS estimates are consistent. Hence, a conclusion that the impact of mother's schooling exceeds that of father's schooling should be viewed with a considerable amount of caution.

The results for the JCEE scores are presented in Table 5. Most colleges require students who want to major in the humanities or the social sciences to take tests in English, Chinese, History, Geography, and Mathematics b. They require students who want to major in the natural sciences or engineering to take tests in English, Chinese, Mathematics a, Chemistry, Physics, and Biology. Therefore, the best way to interpret the results is to compute the average coefficient on the five humanities tests (hereafter termed the humanities cluster) and the average coefficient on the six science tests (hereafter termed the science cluster). The former cluster has a mean score of 48.7, while the latter has a mean score of 44.1.

Before discussing the results, we want to comment on the impact of small differences in the scores. Students who want to major in engineering, chemistry, or physics have to take all the tests in the science cluster except for the biology test. Within that field, electrical engineering was the most popular desired major selected by JCEE test-takers and physics was the second most popular major in 2009. The average score of students who entered National Taiwan University--the best university in Taiwan--with a major in electrical engineering in 2009 was 83.0. The average score of students who entered that university with a major in physics in the same year was 82.3. Hence a difference of only 0.7 points determined whether a student could enter the university with his or her first or second choice of a major.

To cite another example, students who wanted to major in medicine had to take all six tests in the science cluster. The average score of students who entered National Taiwan University with a major in medicine was 87.2. The average score of entrants to National Yang-Miang University--the second best medical school in Taiwan--with a similar major was 85.9. Here a difference of only 1.3 points was the deciding factor. To cite a third example, the most popular major in the social sciences in 2009 was international business and the second most popular major was business administration. Candidates for these two majors had to take all five tests in the humanities cluster. Students who entered National Taiwan University in 2009 with a major in international business had a mean score 78.8, while students who entered that university with a major in business administration had a mean score of 76.9. In this case a difference of 1.9 points sorted the two groups of entrants.[10]

All OLS coefficients in Table 5 are positive and significant. A one-year increase either in mother's schooling or father's schooling increases the humanities cluster score by 0.4 points and increases the science cluster score by 0.6 points. The IV coefficients tell a somewhat different story. All 9 father's schooling coefficients are positive and 7 are significant. The predicted effects of a one-year increase in that schooling variable--0.9 points in the humanities cluster and 1.3 points in the science cluster--are twice as large as the corresponding OLS effects. On the other

[10] The data in this paragraph are taken from http://mag.udn.com/mag/campus/storypage.jsp?f_ART_ID=260543.

hand, a number of the mother's schooling coefficients are negative. A one-year increase in mother's schooling actually lowers the humanities and science cluster scores by 0.1 points and 0.4 points, respectively.

Although the Wu-Hausman test indicates that the OLS coefficients are consistent, the striking difference between the IV and OLS results needs to be addressed. What are the sources of this difference? One explanation is that the impact of a one-year increase in both schooling variables is about the same whether it is obtained by OLS or IV. It amounts to 0.8 points on the humanities test whether the effect is obtained by OLS or IV. The corresponding effect on the science test is 1.2 points with OLS and 0.9 points with IV. According to this explanation, the predicted values of the two schooling variables are too highly correlated in the sample of JCEE test-takers to sort out the separate effects of each.

Another explanation is that one may want to interpret the Wu-Hausman consistency tests with caution because IV estimation results in a loss of efficiency. If that approach is taken, the IV estimates should be stressed. These estimates indicate that father's schooling is a causal determinant of improved JCEE scores, while mother's schooling is not. That explanation is consistent with behaviors in which parents hire tutors or enroll their children in courses to prepare their children for the JCEE.[11] Since father's schooling is a more important determinant of family income than mother's schooling in most families, his schooling is the key indicator of the amount of resources available for this purpose. This interpretation does not rule out an important indirect causal effect of mother's schooling because investments made by mothers in their children prior to the senior year in high school may influence the extent to which they benefit from tutors and preparatory classes. We lack instruments to sort out these two

[11] As of the end of 2006, there were a total of 400 private exam preparation institutions and 183 private English teaching institutions (http://bsb.edu.tw).

explanations.[12]

The finding that parents' schooling has a bigger effect on the science cluster test score than on the humanities cluster test score is notable because graduates from the disciplines covered by the former test command higher earnings than those who graduate from disciplines covered by the latter test. This implies that investments in their children made by more educated parents are guided by monetary returns. In turn, increases in parents schooling should raise the earnings of their children and are part of the source of the intergenerational positive correlation in earnings that is observed in many countries.

In Table 6 we consider the probability of being admitted to college, the probability of being admitted to a public college, and the probability of being admitted to one of the top 6 public colleges as outcomes. The OLS coefficients are all positive and significant. A one-year increase in schooling raises the relevant probability by between 0.6 and 1 percentage point. For each outcome, the mother's schooling coefficient is slightly larger than the father's schooling coefficient. The IV results tell a similar story except that the coefficients in the equation for the probability of attending college have very large standard errors and are not significant. That is not surprising because 71 percent of test-takers enter college. On the other hand, only 26 percent of test-takers enter a public college and only 9 percent enter one of the top 6 public colleges. The IV coefficients imply that a one-year increase in mother's schooling raises the former outcome by approximately 2 percentage points and raises the latter outcome by approximately 1 percentage point. The corresponding increases for father's schooling are approximately 1 percentage point in each case.

[12] The second explanation is consistent with a model in which children's educational outcome depend on the product of mother's schooling and father's schooling in addition to the levels of each variable.

VII. Discussion

Our results imply that parents' schooling causes more favorable educational outcomes for their children when they reach the age of 18 in Taiwan. Children of more educated parents are more likely to take college entrance examinations, to obtain better scores on these examinations, and to gain admittance to a highly ranked college. These findings are robust to estimation by ordinary least squares or instrumental variables. Our study is one of the first to identify separate beneficial effects for the schooling of each parent. That is, most of the outcomes we consider are positively related to the schooling of one parent, with the schooling of the other parent held constant.

Perhaps the most important outcome that we have considered is admittance to one of the top 6 colleges. Hence, our finding that a one-year increase in either mother's schooling or father's schooling raises the likelihood of being admitted to one of the 6 best colleges in Taiwan by approximately 10 percent is striking. It underscores an important nonmarket benefit (a benefit other than an increase in earnings) that accrues to individuals who decide to acquire more years of formal schooling.

The nonmarket benefit just mentioned complements that uncovered by Chou et al. (2010). They employ the same instrument that we employ to show that the increase in parents' schooling associated with compulsory school reform in Taiwan improved birth outcomes and saved almost 1 infant life in 1,000 live births. As argued by Grossman (2006, page 580), "[Knowledge capital and health capital] are the two most important sources of human capital. They interact in their levels and in ways that affect the cost and usefulness of the other." Our study and the one by Chou et al. underscore the causal role played by parental schooling in the acquisition of both types of human capital by their offspring.

References

Antonovics, Kate L., and Arthur S. Goldberger. "Does Increasing Women's Schooling Raise the Schooling of the Next Generation? Comment." *American Economic Review*, December 2005, 95(5), pp.1738–1744.

Behrman, Jere R., and Mark R. Rosenzweig. "Does Increasing Women's Schooling Raise the Schooling of the Next Generation?" *American Economic Review*, March 2002, 92(1), pp.323-34.

Björklund, Anders, Mikael Lindahl, and Erik Plug. "The Origins of Intergenerational Associations: Lessons from Swedish Adoption Data." *Quarterly Journal of Economics*, August 2006, 121(3), pp.999-1028.

Black, Sandra E., Paul J. Devereux, and Kjell G. Salvanes. "Why the Apple Doesn't Fall Far: Understanding Intergenerational Transmission of Human Capital." *American Economic Review*, 95(1), March 2005, pp.437-449.

Bound, John, and Gary Solon. "Double Trouble: Pitfalls in Twins-Based Estimates of the Returns to Schooling." *Economics of Education Review*, April 1999, 18(2), pp.169-182.

Cameron, A. Colin, and Pravin K. Trivedi. *Microeconometrics: Methods and Applications*, Cambridge University Press, 2005.

Card, David. "The Causal Effect of Education on Earnings." In Orley Ashenfelter and David Cards, eds., *Handbook of Labor Economics*, volume III (Amsterdam: Elsevier), 1999, pp.1801-1863.

Card, David. "Estimating the Return to Schooling: Progress on Some Persistent Econometric Problems." *Econometrica*, September 2001, 69(5), pp.1127-1160.

Carneiro, Pedro, Costas Meghir, and Matthias Parey. "Maternal Education, Home Environments and the Development of Children and Adolescents." Centre for Microdata Methods and Practice, Institute for Fiscal Studies, Department of Economics University College of London Working Paper CWP39/10, 2010.

Chevalier, Arnaud. "Parental Education and Child's Education: A Natural Experiment." Institute for the Study of Labor (IZA) Discussion Paper No. 1153, 2004.

Chou, Shin-Yi, Jin-Tan Liu, Michael Grossman, and Theodore J. Joyce. "Parental Education and Child Health: Evidence from a Natural Experiment in Taiwan." *American Economic Journal: Applied Economics*, January 2010, 2(1), pp.33-61.

Clark, Diana E., and Chang-Tai Hsieh. "Schooling and Labor Market Impact of the 1968 Nine-Year Education Program in Taiwan." Working Paper, Department of Economics, Princeton University, June 2000.

de Walque, Damien. "Parental Education and Children's Schooling Outcomes: Evidence from Recomposed Families in Rwanda." *Economic Development and Cultural Change*, July 2009, 57(4), pp.723-746.

Directorate-General of Budgets, Accounts and Statistics (DGBAS), Executive Yuan. *Statistical Abstract of the Republic of China*, 1983.

Duflo, Esther. "Schooling and Labor Market Consequences of School Construction in Indonesia: Evidence from an Unusual Policy Experiment." National Bureau of Economic Research Working Paper 7860, 2000.

Duflo, Esther. "Schooling and Labor Market Consequences of School Construction in Indonesia: Evidence from an Unusual Policy Experiment." *American Economic Review*, September 2001, 91(4), pp.795-813.

Fuchs, Victor R. "Time Preference and Health: An Exploratory Study." *Economic Aspects of Health*, edited by Victor R. Fuchs, Chicago: University of Chicago Press, 1982, pp.93-120.

Griliches, Zvi. "Sibling Models and Data in Economics: Beginnings of a Survey." *Journal of Political Economy*, October 1979, 87(5), pp.S37-64.

Grossman, Michael. "Education and Nonmarket Outcomes." *Handbook of the Economics of Education*, Volume 1 edited by Eric Hanushek and Finis Welch, Amsterdam: North-Holland, Elsevier Science, 2006, pp.577-633

Haveman, Robert, and Barbara Wolfe. "The Determinants of Children's Attainments: A Review of Methods and Findings." *Journal of Economic Literature*, December 1995, 33(4), pp.1829-1878.

Mincer, Jacob A. "Schooling and Earnings." *Schooling, Experience, and Earnings*, edited by Jacob A. Mincer, 1974, pp.41-63.

Ministry of Education (MOE). *Educational Statistics of the Republic of China*, 1968-1971.

Neumark, David. "Biases in Twin Estimates of the Return to Schooling." *Economics of Education Review*, April 1999, 18(2), pp.143-148.

Oreopoulos, Philip, Marianne E. Page, and Ann Huff Stevens. "The Intergenerational Effects of Compulsory Schooling." *Journal of Labor Economics*, October 2006, 24(4), pp.729-760.

Plug, Erik. "Estimating the Effect of Mother's Schooling on Children's Schooling Using a Sample of Adoptees." *American Economic Review*, March 2004, 94(1), pp.358-368.

Roodman, David. "CMP: Stata Module to Implement Conditional (Recursive) Mixed Process Estimator." *Statistical Software Components* with number S456882, Boston College Department of Economics, 2007.

Roodman, David. "Estimating Fully Observed Recursive Mixed-Process Models with cmp." Center for Global Development Working Paper No.168, April 2009.

Sacerdote, Bruce. "How Large Are the Effects from Changes in Family Environment? A Study of

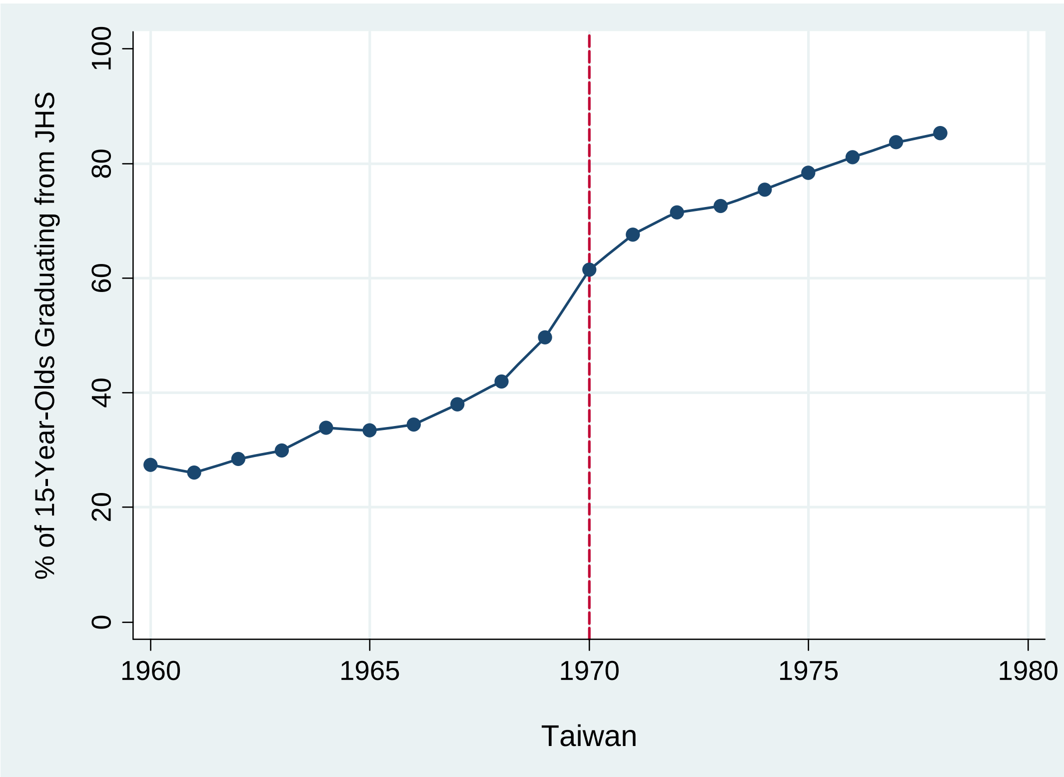
Korean American Adoptees." *Quarterly Journal of Economics*, February 2007, 122(1), pp.119-57.

Solon, Gary. "Intergenerational Mobility in the Labor Market." In Orley Ashenfelter and David Cards, eds., *Handbook of Labor Economics*, volume III (Amsterdam: Elsevier), 1999, pp.1761-1800.

Strauss, John, and Duncan Thomas. "Human Resources: Empirical Modeling of Household and Family Decisions." In Jere Behrman and T.N. Srinivasan, eds., *Handbook of Development Economics*, volume III (Amsterdam: Elsevier), 1995, pp.1883-2023.

Tsai, Wehn-Jyuan. *Three Essays on Applied Microeconometrics: Education Policy, Intergenerational Schooling Effect and Value of a Statistical Life*. Ph.D. dissertation, National Taiwan University, 2007.

Figure 1: Percentage of 15-Year-Olds Graduating from Junior High School, 1960-1978



Source: *Education Statistics of the Republic of China*, Ministry of Education, 2004

Table 1

Cumulative Number of New Junior High School Openings per Thousand Children Ages 12-14, by School Year and County, 1968-1973

County	1968	1969	1970	1971	1972	1973
Taipei City	0.188	0.222	0.223	0.217	0.211	0.214
Taichung City	0.124	0.150	0.234	0.227	0.218	0.210
Keelung City	0.162	0.156	0.153	0.152	0.150	0.150
Tainan City	0.086	0.111	0.136	0.134	0.133	0.132
Kaohsiung City	0.018	0.052	0.081	0.078	0.075	0.101
Taipei County	0.135	0.186	0.189	0.254	0.214	0.204
Ilan County	0.062	0.153	0.211	0.240	0.265	0.266
Taoyuan County	0.100	0.134	0.130	0.144	0.191	0.182
Chaiyi County	0.070	0.125	0.167	0.168	0.183	0.200
Hsinchu County	0.045	0.133	0.154	0.174	0.193	0.190
Miaoli County	0.119	0.164	0.185	0.184	0.182	0.181
Taichung County	0.220	0.219	0.234	0.251	0.249	0.245
Nantou County	0.166	0.164	0.258	0.330	0.401	0.402
Changhua County	0.024	0.035	0.047	0.059	0.071	0.071
Yunlin County	0.106	0.106	0.152	0.169	0.200	0.200
Tainan County	0.229	0.228	0.228	0.228	0.255	0.257
Kaohsiung County	0.016	0.046	0.061	0.075	0.133	0.130
Pingtung County	0.195	0.193	0.222	0.221	0.220	0.219
Hualien County	0.385	0.410	0.408	0.408	0.408	0.408
Taitung County	0.424	0.540	0.578	0.579	0.578	0.578
Penghu County	0.529	0.516	0.708	0.803	0.904	0.911
Country as a whole	**0.136**	**0.164**	**0.188**	**0.201**	**0.212**	**0.212**

Note: Denominator pertains to children ages 12-14 in a given year. The figure for the country as a whole is a weighted average of the figures for each county where the set of weights is the county-specific number of children 12-14.
Sources: Ministry of Education, Fourth Education Yearbook of the Republic of China, 1974 and web sites of selected schools for the number of new junior high schools, 1968-1972; the web site of each individual school for 1973; and Directorate-General of Budgets, Accounts, and Statistics, Executive Yuan, Statistical Abstract of the Republic of China, 1983 for the population ages 12-14 in 1968-1973. Table originally appeared in Chou et al. (2010).

Table 2: Sample Statistics

	Mean	Std. Dev.	Sample Size
Panel A: Child Education Outcomes			
Exam-Takers	0.256	(0.437)	1,118,879
Among exam-takers, their …			
Scores in Competency Test (February)			
Chinese	10.979	(2.066)	196,156
English	8.760	(3.070)	196,156
Math	7.224	(3.315)	196,156
Social Sciences	11.140	(2.328)	196,156
Natural Sciences	9.421	(2.533)	196,156
Total Score	47.536	(9.650)	196,156
Scores in JCEE (July)			
Chinese	53.248	(14.506)	232,857
English	44.391	(22.251)	232,759
Math (b)	44.479	(22.122)	169,911
History	45.298	(17.892)	140,027
Geography	55.918	(18.363)	139,272
Math (a)	46.573	(22.200)	109,362
Chemistry	40.150	(22.275)	103,300
Physics	32.609	(22.962)	102,892
Biology	47.925	(21.028)	67,510
College Attendance Outcomes			
College	0.708	(0.455)	286,698
Public College	0.259	(0.438)	286,698
Top 6 College	0.092	(0.290)	286,698
Panel B: Parental Education			
Mother's Years of Schooling, Entire Sample	8.812	(3.434)	1,118,879
Father's Years of Schooling, Entire Sample	9.721	(3.462)	1,118,879
Mother's Years of Schooling, Exam Takers	10.454	(3.335)	286,698
Father's Years of Schooling, Exam Takers	11.466	(3.317)	286,698

Table 3: Estimates of First Stage and Selection EquationsS

	IV Model	OLS Model
Panel A: First Stage		
Mother's Years of Schooling	0.609***	
Treatment Indicator*Program Intensity	[3.11]	
Father's Years of Schooling		
Treatment Indicator*Program Intensity	0.635***	
	[2.84]	
Panel B: Exam Participation		
	0.024***	0.018***
Mother's Years of Schooling	[6.68]	[63.30]
	0.018***	0.023***
Father's Years of Schooling	[4.80]	[64.74]
Sample Size	1,118,879	1,118,879

Note: These coefficients are taken from the full IV model given by equations (1)-(4). There are 18 estimates of this system since there are 18 dependent variables for test-takers in panel A of Table 2. We only report one set of the coefficients here. T-ratios, reported in brackets, are computed from standard errors that adjust for clustering by mother's and father's county of birth pair.
***Significant at the 1 percent level (two-tailed test). **Significant at the 5 percent level (two-tailed test). *Significant at the 10 percent level (two-tailed test).

Table 4: Effects of Parents' Schooling on February Competency Test Scores

	Chinese	English	Math	Social Sciences	Natural Sciences	Total
OLS Model						
Mother's Years of Schooling	0.050***	0.092***	0.067***	0.033***	0.053***	0.294***
	[5.11]	[9.49]	[7.36]	[2.89]	[5.89]	[17.75]
Father's Years of Schooling	0.043***	0.089***	0.059***	0.028**	0.044***	0.263***
	[3.65]	[7.07]	[5.15]	[1.97]	[3.78]	[14.25]
IV Model						
Mother's Years of Schooling	0.019	0.028	0.080***	0.067***	0.034	0.209**
	[1.45]	[1.60]	[4.36]	[6.77]	[0.37]	[2.53]
Father's Years of Schooling	0.009	0.081***	0.094***	-0.090***	0.047	0.110
	[0.84]	[5.15]	[5.26]	[-8.84]	[0.57]	[1.47]
Wu-Hausman Test						
Residual in Score Equation	[0.78]	[1.65]	[-0.15]	[0.86]	[0.46]	[0.93]
Residual in Participation Equation	[-0.76]	[-0.76]	[-0.76]	[-0.76]	[-0.76]	[-0.76]
Joint Significance in Both Equations (x^2)	1.494	3.310	0.603	1.412	0.738	1.505
Prob>x^2	0.474	0.191	0.740	0.494	0.691	0.471

Note: OLS model is the estimation that only includes equations (3) and (4). IV model is the estimation that includes equations (1)-(4). T-ratios, reported in brackets, are computed from standard errors that adjust for clustering by mother's and father's county of birth pair.
***Significant at the 1 percent level (two-tailed test). **Significant at the 5 percent level (two-tailed test). *Significant at the 10 percent level (two-tailed test).

Table 5: Effects of Parents' Schooling on July JCEE Test Scores

	Chinese	English	Math (b)	History	Geography	Math (a)	Chemistry	Physics	Biology
OLS Model									
Mother's Years of Schooling	0.342***	0.718***	0.427***	0.375***	0.291***	0.515***	0.611***	0.615***	0.619***
	[11.53]	[24.60]	[4.09]	[13.55]	[10.94]	[15.26]	[12.54]	[14.15]	[17.12]
Father's Years of Schooling	0.324***	0.736***	0.386***	0.329***	0.276***	0.507***	0.601***	0.589***	0.592***
	[8.73]	[26.90]	[2.69]	[8.80]	[9.28]	[13.16]	[11.90]	[13.06]	[14.51]
IV Model									
Mother's Years of Schooling	-0.243	-1.476***	0.661***	0.378***	0.296***	-0.535***	-0.248***	0.143	-0.067
	[-0.06]	[-8.53]	[3.04]	[4.97]	[2.65]	[-4.30]	[-2.94]	[0.77]	[-0.87]
Father's Years of Schooling	0.643	2.681***	1.071***	0.314***	0.078	1.017***	1.131***	1.284***	0.817***
	[0.12]	[15.09]	[5.56]	[4.14]	[0.74]	[10.78]	[12.11]	[7.00]	[10.52]
Wu-Hausman Test									
Residual in Score Equation	[2.59]	[1.79]	[0.05]	[0.48]	[0.49]	[2.57]	[1.71]	[0.80]	[1.12]
Residual in Participation Equation	[-0.76]	[-0.76]	[-0.76]	[-0.76]	[-0.76]	[-0.76]	[-0.76]	[-0.76]	[-0.76]
Joint Significance in Both Equations (x^2)	7.786	3.677	0.575	0.947	0.971	6.628	3.183	1.147	1.780
Prob>x^2	0.0204	0.159	0.750	0.623	0.615	0.0364	0.204	0.563	0.411

Note: OLS model is the estimation that only includes equations (3) and (4). IV model is the estimation that includes equations (1)-(4). T-ratios, reported in brackets, are computed from standard errors that adjust for clustering by mother's and father's county of birth pair.
***Significant at the 1 percent level (two-tailed test). **Significant at the 5 percent level (two-tailed test). *Significant at the 10 percent level (two-tailed test).

Table 6: Effects of Parents' Schooling on College Attendance

	Attending		
	College	Public College	Top 6 College
OLS Model			
	0.008***	0.010***	0.007***
Mother's Years of Schooling	[3.04]	[6.34]	[17.29]
	0.007**	0.009***	0.006***
Father's Years of Schooling	[2.16]	[4.56]	[15.77]
IV Model			
	0.000	0.016***	0.013***
Mother's Years of Schooling	[0.00]	[3.46]	[5.57]
	0.012	0.011**	0.008***
Father's Years of Schooling	[0.15]	[2.44]	[4.23]
Wu-Hausman Test			
Residual in Score Equation	[1.39]	[-0.77]	[-1.35]
Residual in Participation Equation	[-0.76]	[-0.76]	[-0.76]
Joint Significance in Both Equations (x^2)	2.407	1.445	2.833
Prob>x^2	0.300	0.486	0.243

Note: OLS model is the estimation that only includes equations (3) and (4). IV model is the estimation that includes equations (1)-(4). T-ratios, reported in brackets, are computed from standard errors that adjust for clustering by mother's and father's county of birth pair.
***Significant at the 1 percent level (two-tailed test). **Significant at the 5 percent level (two-tailed test). *Significant at the 10 percent level (two-tailed test)