Parental Education and Child Health: Evidence from a Natural Experiment in Taiwan

Shin-Yi Chou
Lehigh University and National Bureau of Economic Research

Jin-Tan Liu
National Taiwan University and National Bureau of Economic Research

Michael Grossman
City University of New York Graduate Center and National Bureau of Economic Research

Ted Joyce
Baruch College and National Bureau of Economic Research

Research for the paper was supported by grant number 5 R01 HD045603 from the National Institute of Child Health and Human Development to the National Bureau of Economic Research.

OVERVIEW

- **"The one social factor that researchers agree is consistently linked to longer lives in every country where it has been studied is education. It is more important than race; it obliterates any effects of income." Gina Kolata, "A Surprising Secret to Long Life: Stay in School," *New York Times*, January 3, 2007**

- **<u>Research question:</u>**
  Is the positive relationship between parental educational attainment and the health of their children causal?

- **<u>Difficulty:</u>**
  Unobserved characteristics that affect both parents' education levels and the health of their children.

- **<u>Our strategy:</u>**
  Employ compulsory school reform in Taiwan in 1968 as an instrument for education

HEALTH-SCHOOLING CAUSALITY CONTROVERSY

- **Extensive literature suggests**

  Years of formal schooling that a person completes is most important correlate of his or her health

  Parents' schooling most important correlate of health of their children

CHALLENGES

- **Causal nature of schooling effect questioned on grounds of omitted third variables or reverse causality**

- **Time preference hypothesis of Victor Fuchs (1982): persons who are more future oriented attend school for longer periods of time and make larger investments in their own health and the health of their children**

- **Reverse causality:**

  Longer life expectancy increases payoffs to investments in schooling

  Parents' schooling as input into production of child health

- **Third variable hypothesis has received most attention; analogous to hypothesis that positive effect of schooling on earnings biased by omission of ability**

TWO-EQUATION STRUCTURAL MODEL

$$S = S(P_S, H, U) \qquad (1)$$

$$H = H(P_H, S, U) \qquad (2)$$

REDUCED FORM

$$S = S(P_S, P_H, U) \qquad (3)$$

$$H = H(P_S, P_H, U) \qquad (4)$$

- **Price of Schooling (P_s), Price of Health (P_H), Unobservable (U)**
- **Aim: Estimate equations (2), (3), (4), no measure of P_H**
- **Program intensity the instrument for S**

INSTRUMENTAL VARIABLES APPROACH

- **Fourteen studies since 2002 employ instrumental variables techniques to obtain consistent estimates of causal schooling effect**

- **Studies: Lleras-Muney (2005), Adams (2002), Arendt (2005, forthcoming), Spasojevic (2003), Oreopoulos (2006), de Walque (2007), Grimard and Parent (2007), Cipollone, Radicchia, and Rosolia (2007), Arkes (2004), Kenkel, Lillard, and Mathios (2006), Currie and Moretti (2003), Breierova and Duflo (2004), McCrary and Royer (2006)**

- **Instruments: Compulsory education laws, exemption from military service, unemployment rates during teenage years, requirements for high school completion and GED degree, primary school or college openings, age-at-school entry policies**

- **IV effects at least as large as OLS effects**

- **Only three of the 14 studies deal with children's health and only one considers a developing country**

BACKGROUND: COMPULSORY EDUCATION REFORM IN TAIWAN, 1968

- **Extended from 6 years to 9 years**
- **150 new junior high schools were opened at the beginning of school year 1968-69 (Sept 1, 1968)--50% increase**
- **By 1973, an additional 104 junior high schools had opened**
- **Number of schools per thousand children ages 12-14 rose from 0.3 in school year 1967 to 0.4 in school year 1968, and to 0.5 in school year 1973**
- **Percentage of primary school graduates who entered junior high school rose from 62 percent in 1967, to 75 percent in 1968, and to 84 percent in 1973**
- **Intensity of new school construction varied across regions (counties) of Taiwan**

Figure 1.
Percentage of Primary School Graduates Entering Junior High School

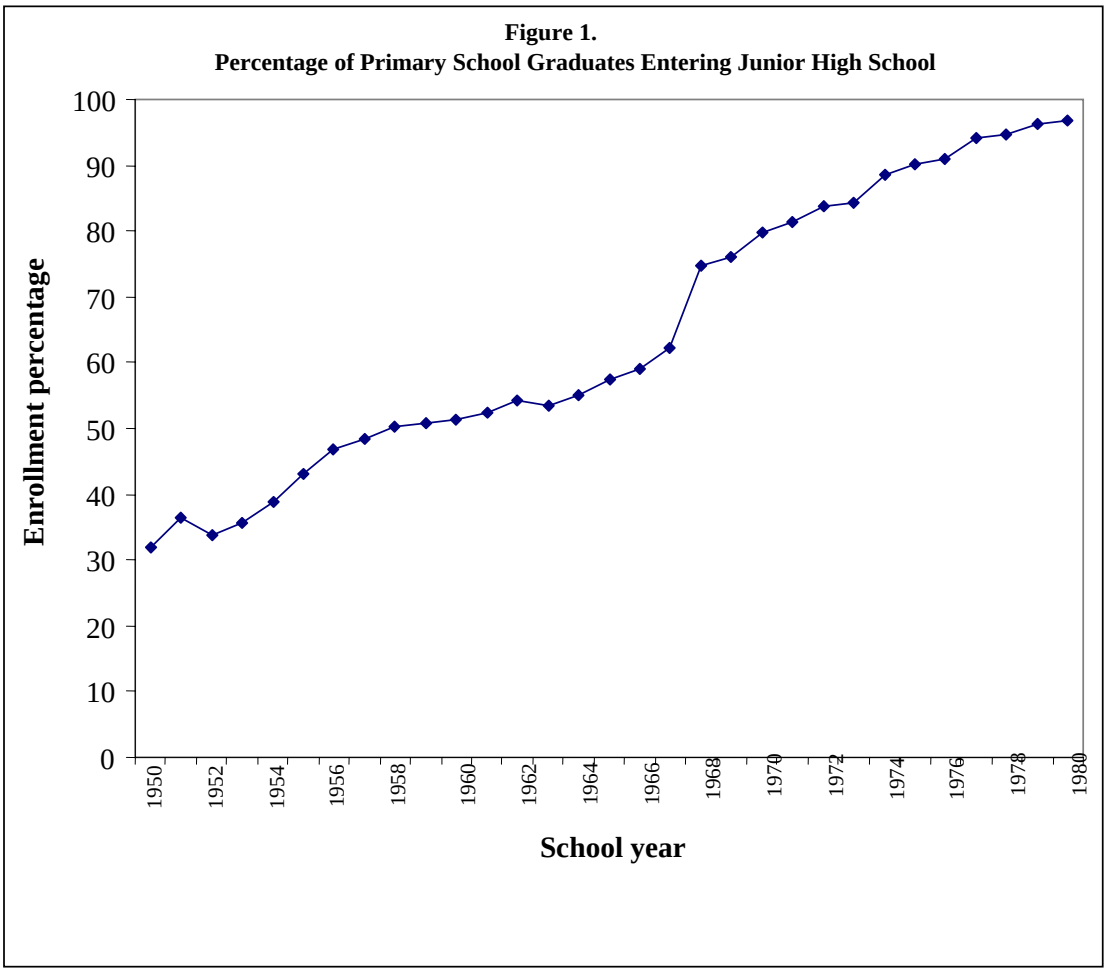


Table 1

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

IDENTIFICATION STRATEGY

- **Treatment/Control Groups: women or men age 12 or under in 1968 on one hand and between ages of 13 and 20 or 25 on other hand**

- **Within each region, exploit variations across cohorts in new junior high school openings to form an instrument for schooling**

- **Instrument: products of cohort indicators and program intensity measure in Table 1 in regression with cohort and county fixed effects**

- **Use instrument to estimate causal effects of mother's or father's schooling on incidence of low birthweight and mortality of infants born to women in the treatment and control groups or the wives of men in these groups in the period from 1978-1999**

DATA

- **Birth and infant death certificates for 1978-1999**

- **Outcomes: probability of low-weight (less than 2,500 grams) birth, probabilities of neonatal, postneonatal, and infant death**

- **Sample for mother's schooling: births to women between ages of less than 1 and 20 in 1968 and between 22-45 when they gave birth**

- **Sample for father's schooling: births to wives of husbands who were between ages of less than 1 and 25 in 1968 and between ages of 22-50 when their wives gave birth**

- **Aggregate data into mother's or father's county of birth, mother's or father's cohort in 1968, and child's year of birth cells**

PRELIMINARY INVESTIGATION OF EFFECTS OF INSTRUMENT ON SCHOOLING-INTRODUCTION

- **DD, RDD, and LPM models**

- **Pure treatment group-control group methodology adjusted for trends, does not employ program intensity measure**

- **Individual data from birth certificates, mothers or fathers ages 25-34 at birth of child**

- **Also Taiwan KAP (knowledge, attitudes, and practice of family planning and reproductive health) surveys, women 25-34 at time of survey, 1980, 1986, 1992, and 1998 surveys**

  Limited sample size but assess impact of school reform from population-based survey of married women

DD and RDD SPECIFICATIONS: TABLE 2

DD

- **Treatment group 11-12 years old in 1968**
- **Control group 14-15 in 1968**
- **Control for trend: difference in schooling between those 6-7 in 1968 and those 9-10**
- **Standard errors adjusted for clustering by age**

$$S_i = \alpha_0 + \beta_0 C_{6\text{-}7} + \beta_1 C_{9\text{-}10} + \beta_2 C_{11\text{-}12}$$

- **S_i number of years of schooling completed by ith person**
- **Independent variables: cohort indicators, omitted category 14-15**
- **DD: $[\beta_2 - (\beta_0 - \beta_1)]$**

RDD

$$S = \alpha_0 + \alpha_1 \text{Treat} + \alpha_2 \text{Age68} + \alpha_3 (\text{Age68})^2$$

- **Treat = 1 if age in 1968 < 13**
- **Include all men and women ages 0-15 in 1968, standard errors clustered by age**

Table 2

Cohort Differences in Educational Attainment by Gender and Source: Taiwanese Women and Men 25-34 Years of Age at Time of Birth or Survey[a] (Dependent Variable: Years of Completed Schooling)

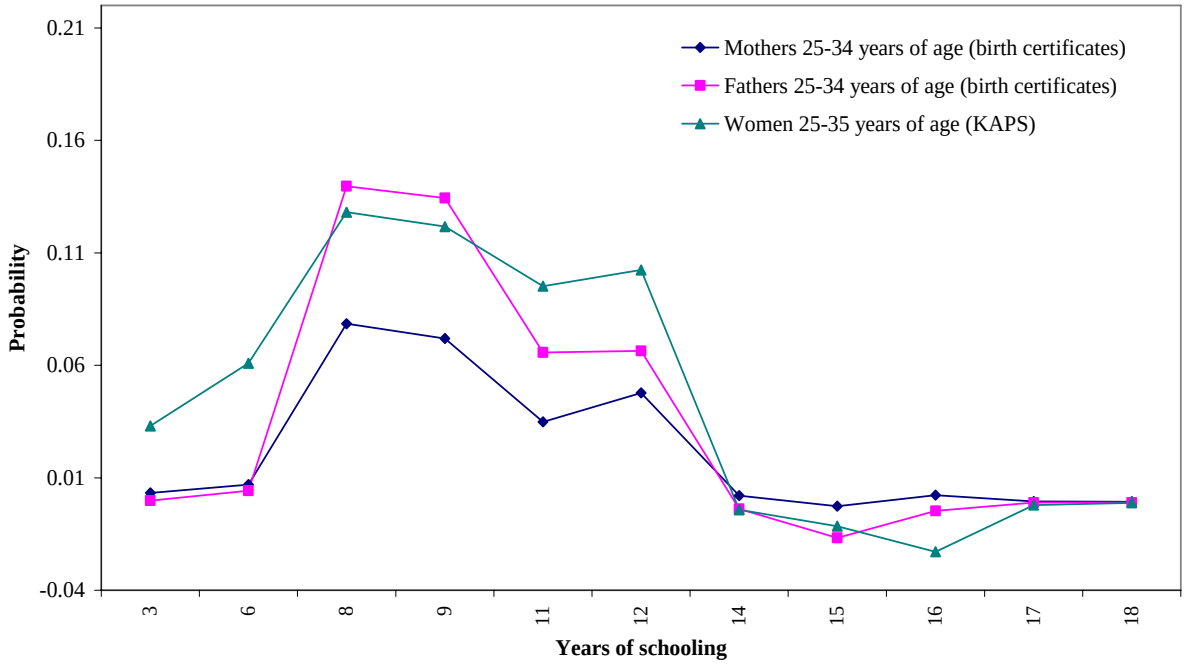
	Women		Men
	Birth certificates	*KAPS*	*Birth certificates*
Age in 1968:			
a. 6-7 years	**10.42**	**9.84**	**10.80**
b. 9-10 years	**9.84**	**9.26**	**10.52**
c. 11-12 years	**9.36**	**8.89**	**10.24**
d. 14-15 years	**8.41**	**7.38**	**9.38**
Difference-in-differences:			
Rows (c-d) - (a-b)	**0.3838****	**0.9212*****	**0.5944*****
	(2.14)	**(4.41)**	**(4.52)**
Sample Size	**1,631,788**	**4,467**	**2,158,871**
Regression discontinuity[b]	**0.1469****	**0.6337*****	**0.2806*****
	(2.30)	**(3.57)**	**(4.60)**
Sample size	**3,370,393**	**8,489**	**4,036,886**

LPM: FIGURE 2

$$S_{im} = \alpha_0 + \beta_0 C_{6\text{-}7} + \beta_1 C_{9\text{-}10} + \beta_2 C_{11\text{-}12}$$

- **S_{im} = 1 if person i completed at least m years of formal schooling (m = 3, 4,...,16), 14 regressions**
- **Independent variables: cohort indicators used in DD**
- **Compute separate DD for each regression [$\beta_2 - (\beta_0 - \beta_1)$]**

Figure 2.
Probability of Completing at Least "M" Years of Schooling Associated with 1968 Reform in Taiwan



PRELIMINARY INVESTIGATION OF EFFECTS OF INSTRUMENT ON SCHOOLING: INCORPORATION OF INTENSITY

$$S_{aj} = \alpha_{20} + \sum_{a=0}^{19} (\alpha_a - \alpha_{20}) C_a + \sum_{j=1}^{20} \phi_j D_j + \sum_{a=0}^{12} \beta_a C_a P_{aj}$$

- **S_{aj}: years of formal schooling completed by cohort a in county j**
- **C_a: cohort dummies, capture trends in schooling not associated with compulsory school reform**
- **D_j: county dummies, control for cohort-invariant unmeasured factors that may vary among counties and may be correlated with schooling and program intensity**
- **P_{aj}: program intensity defined as county-specific cumulative number of new junior high schools per thousand children ages 12-14 in the year in which cohort entered junior high school**
- **Standard errors corrected for clustering at county level**

Table 3

Effects of Educational Reform on Parents' Years of Formal Schooling Completed

Program intensity*cohort	Mother's schooling (mean=9.53)	Father's schooling (mean=10.12)
Age < 1 in 1968	0.707 (1.16)	1.013 (2.10)**
Age = 1 in 1968	0.789 (1.43)*	0.731 (1.77)**
Age = 2 in 1968	0.685 (1.36)*	0.696 (1.52)*
Age = 3 in 1968	0.703 (1.51)*	0.606 (1.53)*
Age = 4 in 1968	0.557 (1.54)*	0.666 (1.69)*
Age = 5 in 1968	0.636 (1.65)*	0.597 (1.42)*
Age = 6 in 1968	0.526 (1.69)*	0.682 (1.73)**
Age = 7 in 1968	0.615 (2.18)**	0.699 (1.74)**
Age = 8 in 1968	0.478 (1.54)*	0.871 (2.16)**
Age = 9 in 1968	0.489 (1.93)**	0.572 (1.50)*
Age =10 in 1968	0.611 (2.55)***	0.726 (2.41)**
Age =11 in 1968	0.486 (2.19)**	0.710 (2.53)***
Age =12 in 1968	0.511 (1.97)**	0.825 (2.50)**
F-test 0,…,12	28.58	16.62
Observations	7853	10242
R-squared	0.96	0.92

FINAL EMPRICIAL IMPLEMENATION: REDUCED FORM SCHOOLING SPECIFICATION

$$S_{aj} = \alpha_{20} + \sum_{a=0}^{19}(\alpha_a - \alpha_{20})C_a + \sum_{j=1}^{20}\phi_j D_j + \beta T_a P_{aj}$$

- **S_{aj}: years of formal schooling completed by cohort a in county j**
- **C_a: cohort dummies, capture trends in schooling not associated with compulsory school reform**
- **D_j: county dummies, control for cohort-invariant unmeasured factors that may vary among counties and may be correlated with schooling and program intensity**
- **T_a: dummy for treatment group**
- **P_{aj}: program intensity defined as county-specific cumulative number of new junior high schools per thousand children ages 12-14 in the year in which cohort entered junior high school**

EMPIRICAL IMPLEMENATION: REDUCED FORM AND STRUCTURAL HEALTH OUTCOME EQUATIONS

- **Cox's modified logistic transformation to dependent variables in health outcome equations since a number of cells have no low-weight births or no deaths**

- **$Y_i \equiv N_i/D_i$: one of four health outcomes in ith cell**

- **Dependent variable**

$$\ln Z_i = \ln \frac{Y_i + \frac{1}{2D_i}}{1 - Y_i + \frac{1}{2D_i}} = \ln \frac{N_i + 0.5}{D_i - N_i + 0.5}$$

- **Regression employs set of weights given by**

$$W_i = \left[\frac{D_i(N_i + 1)(D_i - N_i + 1)}{(D_i + 1)(D_i + 2)} \right]^{1/2}$$

- **Standard errors always adjusted for clustering at county level**

Table 4

Effects of Educational Reform on Parents' Years of Formal Schooling Completed

	Mother's schooling				Father's schooling			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Treatment*program intensity (mean=0.20)	1.288***	1.045***	1.302***	1.240***	1.143***	0.805*	1.087**	1.094**
	(3.57)	(3.19)	(3.71)	(3.71)	(2.93)	(1.66)	(2.27)	(2.37)
R-squared	0.926	0.844	0.856	0.882	0.889	0.800	0.812	0.838
Observations	7853	7853	7853	7853	10242	10242	10242	10242

Table 5

Effects of Program Intensity and Mother's Schooling on Infant Health

	Low birthweight	Neonatal mortality	Postneonatal mortality	Infant mortality
Panel A - *Reduced Form Infant Health Cox Modified Logit Regressions, Weighted Least Squares*				
Treatment*program intensity	**-0.249*** (-2.81)**	**-0.333*** (-3.35)**	**-0.835*** (-5.49)**	**-0.626*** (-5.65)**
R-squared	**0.445**	**0.499**	**0.333**	**0.365**
Mean*100 (or 1000)	**4.30**	**2.32**	**3.57**	**5.89**
Panel B - *Structural Infant Health Cox Modified Logit Regressions, Weighted Least Squares*				
Mother's schooling	**-0.226*** (-7.48)**	**-0.426*** (-22.99)**	**-0.463*** (-23.69)**	**-0.386*** (-22.04)**
R-squared	**0.534**	**0.571**	**0.453**	**0.463**
Panel C - *Structural Infant Health Cox Modified Logit Regressions, Weighted Two-Stage Least Squares*				
Mother's schooling	**-0.194** (-2.36)**	**-0.318** (-2.01)**	**-0.641** (-2.49)**	**-0.505** (-2.45)**
R-squared	**0.532**	**0.566**	**0.435**	**0.454**
Wu-Hausman F-ratio	**0.23**	**0.32**	**0.69**	**0.46**

Table 6

Effects of Program Intensity and Father's Schooling on Infant Health

	Low birthweight	Neonatal mortality	Postneonatal mortality	Infant mortality
Panel A - *Reduced Form Infant Health Cox Modified Logit Regressions, Weighted Least Squares*				
Treatment*program intensity	**-0.216*** (-3.60)**	**-0.196* (-1.43)**	**-0.634*** (-5.42)**	**-0.469*** (-4.95)**
R-squared	**0.374**	**0.461**	**0.353**	**0.371**
Mean*100 (or 1000)	**4.45**	**2.34**	**3.63**	**5.97**
Panel B - *Structural Infant Health Cox Modified Logit Regressions, Weighted Least Squares*				
Father's schooling	**-0.253*** (-9.48)**	**-0.434*** (-21.87)**	**-0.442*** (-23.13)**	**-0.369*** (-21.06)**
R-squared	**0.483**	**0.526**	**0.443**	**0.450**
Panel C - *Structural Infant Health Cox Modified Logit Regressions, Weighted Two-Stage Least Squares*				
Father's schooling	**-0.189** (-2.47)**	**-0.243 (-0.89)**	**-0.584* (-1.64)**	**-0.429* (-1.71)**
R-squared	**0.476**	**0.514**	**0.434**	**0.448**
Wu-Hausman F-ratio	**0.53**	**0.25**	**0.23**	**0.07**

Table 7
Reductions in Low Birthweight and Mortality Due to Increases in Schooling

	Mother's schooling		Father's schooling	
Outcome	Weighted least squares	Weighted two-stage least squares	Weighted least squares	Weighted two-stage least squares
Low birthweight				
Percentage point reduction	0.237	0.204	0.246	0.185
Percentage reduction in number of light births	5.512	4.744	5.528	4.157
Neonatal mortality				
Reduction in number of deaths per thousand live births	0.258	0.195	0.211	0.120
Percentage reduction in number of deaths	11.121	8.405	9.017	5.128
Postneonatal mortality				
Reduction in number of deaths per thousand neonatal survivors	0.492	0.665	0.404	0.526
Percentage reduction in number of deaths	13.782	18.627	11.129	14.490
Infant mortality				
Reduction in number of deaths per thousand live births	0.600	0.774	0.521	0.602
Percentage reduction in number of deaths	10.187	13.141	8.727	10.084

DISCUSSION

- **Results suggest parents' schooling, especially mother's schooling, causes favorable infant health outcomes**

- **Results also suggest that schooling can be treated as exogenous in estimating these effects**

- **Last finding puzzling; schooling clearly an endogenous variable**

- **Literal interpretation: schooling-health system recursive rather than simultaneous with uncorrelated disturbance terms**

- **But too narrow and too naive**

  Infant health benefits of investments in schooling may be small relative to other benefits, making a recursive specification approximately correct

  Disturbance terms in two equations may share a common element such as time preference, but variations in time preference may be small relative to observed determinants of schooling such as its price