Microeconometric Evidence on the Role of Schooling in the Growth Process

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In 2001, Alan Krueger and Mikail Lindah published a review article "Education for Growth: Why and for Whom?"

It is a useful benchmark for gaging the progress in microeconometric research on schooling and growth over the last 15 years or so (they missed a few things)

In that article, the micro evidence on the contributions of schooling was solely based on Mincer earnings equations estimated in the US and around the world

But, Mincer earnings functions are not reliably estimated in low-income countries, where the majority of workers do not work for wages

More importantly, while the micro-based "returns" estimates from simple wage functions are useful, what is needed is an understanding of

(i) the roles of schooling in the mechanisms of economic growth and

(ii) why schooling returns might vary - over countries, over time and by gender

Assess the microeconometric evidence, beyond estimation of Mincer earnings equations, on the role of schooling in fostering growth

A variety of methods have been used, applied to new data:

structural, natural experiments (policy change, technology change), natural natural experiments (twins), RCT's

Issues addressed are closely connected to the mechanisms identified in growth models:

1. Schooling, post-school learning and learning externalities in technology adoption and use

2. Technological change effects on the returns to schooling

3. Fertility effects on schooling and the fertility response to changing schooling returns

4. Schooling and the production of schooling

5. Gender, occupation, schooling and growth

Schooling and growth: Some ideas from growth theory

1. Exogenous growth models: growth determined by technological change

   A. Nelson and Phelps (1966): more rapid adoption of new technology facilitates growth

      Does schooling facilitate new technology adoption? Why?

2. Endogenous growth models

   A. Romer: accumulation of ideas, knowledge embodied in capital stock

      A central point is that there are learning externalities: *new* knowledge embedded in investments in new machines by individual firms spillover

      Is there learning? Is there learning from others?

      Does schooling facilitate learning?

B. Lucas: non-diminishing returns to human capital

Human capital is productive

Higher growth from greater productivity of human capital in producing human capital

Additions to human capital are greater the higher the level of human capital: implies leaning from others is key

Is schooling always productive?

On what does schooling productivity depend?

Does a higher level of schooling facilitate the production of schooling?

Again, are there learning externalities?

3. Transition from Malthusian equilibrium to steady-state growth ("unified growth theory," Lucas)

Key elements:

A. Technological change-induced rise in return to schooling

Is there evidence for this?

B. Consequent increase in schooling investment

Do increases in returns to schooling induce more schooling investment?

C. Shifting resources away from having large families to schooling them

This is the quantity-quality hypothesis

Is there evidence that shifts to schooling investment lowers fertility, and vice versa?

Microeconometric evidence on learning and schooling

Challenge: master how to use a new technology (Foster and Rosenzweig, 1996)

Target-input model:

$$\pi_{jt} = \lambda[\eta_j - (\theta_{jt} - \theta_{jt}^o)^2]$$

where

π_{jt} = profits

η_j = best-use profitability of new technology

λ = operational scale parameter

θ_{jt} = input chosen at time t by farmer j

θ_{jt}^o = *stochastic* optimal input level at time t, normally distributed $N(\theta^*, \sigma^2_u)$

Farmers have priors over θ^*, also normally distributed with posterior variance at time t $\sigma^2_{\theta jt}$

Substituting,

$$\pi_{jt} = \lambda[\eta_j - \sigma^2_{\theta jt} - \sigma^2_u] + \varepsilon_{jt}$$

Bayesian updating implies

$$\sigma^2_{\theta jt} = 1/\ (\rho_0 + \rho_l N_{jt}),$$

where

$$\rho_0 = 1/\sigma^2_0 \qquad\qquad \rho_l = 1/\sigma^2_u$$

N_{jt} = prior experience with the new technology

Implications:

1. Profits in period t depend on cumulated experience

2. Profits thus rise over time, at a diminishing rate (Bayesian)

3. Returns to learning positively related to scale and/or technology efficacy (λ)

Now, assume schooling affects the two types of precision

$\rho_0 = \rho_0(E_j)$, $\rho_0' > 0$ [info advantage] $\rho_l = \rho_l(E_j)$, $\rho_l' > 0$ [learning]

If schooling affects initial information *or* learning, then higher profits for the more schooled:

$$\partial\pi_{jt}/\partial E_j = \lambda[(\rho_0' + \rho_l' N_{jt})/(\rho_0 + \rho_l N_{jt})^2] > 0$$

More schooled will more likely adopt the new technology and faster, since reap higher return, and possibly from experimenting early

Can one identify the learning effect of schooling?

$$\partial\pi_{jt}/\partial E_j \partial N_{jt} = \lambda\{[-2\rho_l\rho_0' + \rho_l'(\rho_0 - \rho_l N_{jt})]/(\rho_0 + \rho_l N_{jt})^3\}$$

If $\rho_l' = 0$, no learning, then the effects of schooling diminishes with experience (schooling and experience are substitutes)

If ρ_0' small and $\rho_l'>0$, then the effect of experience on profits is greater for the more schooled - profit trajectory steeper (faster learning)

Empirically, in increasing level of difficulty:

A. Show *no* schooling effect on productivity where nothing to learn

B. Show more schooled use more of the new technology or adopt first <u>but</u> only *if* the technology requires learning - is complex

C. Show more schooled have higher returns from new technology, <u>but</u> only *if* the technology requires learning - is complex

D. Establish learning taking place: productivity rises at a diminishing rate (Bayesian learning) with new technology

E. Show learning faster with higher level of schooling

A. There are no benefits to schooling in terms of productivity where there is nothing to learn

1. Duflo *et al.* (2011): schooling level of Kenyan farmers exhibited no effect of schooling on profitability; no reports of learning from others

Setting where no new technologies available

2. Philippine harvesters, paid with piece rate wages:

No relationship between schooling and wages

Only a relationship with height

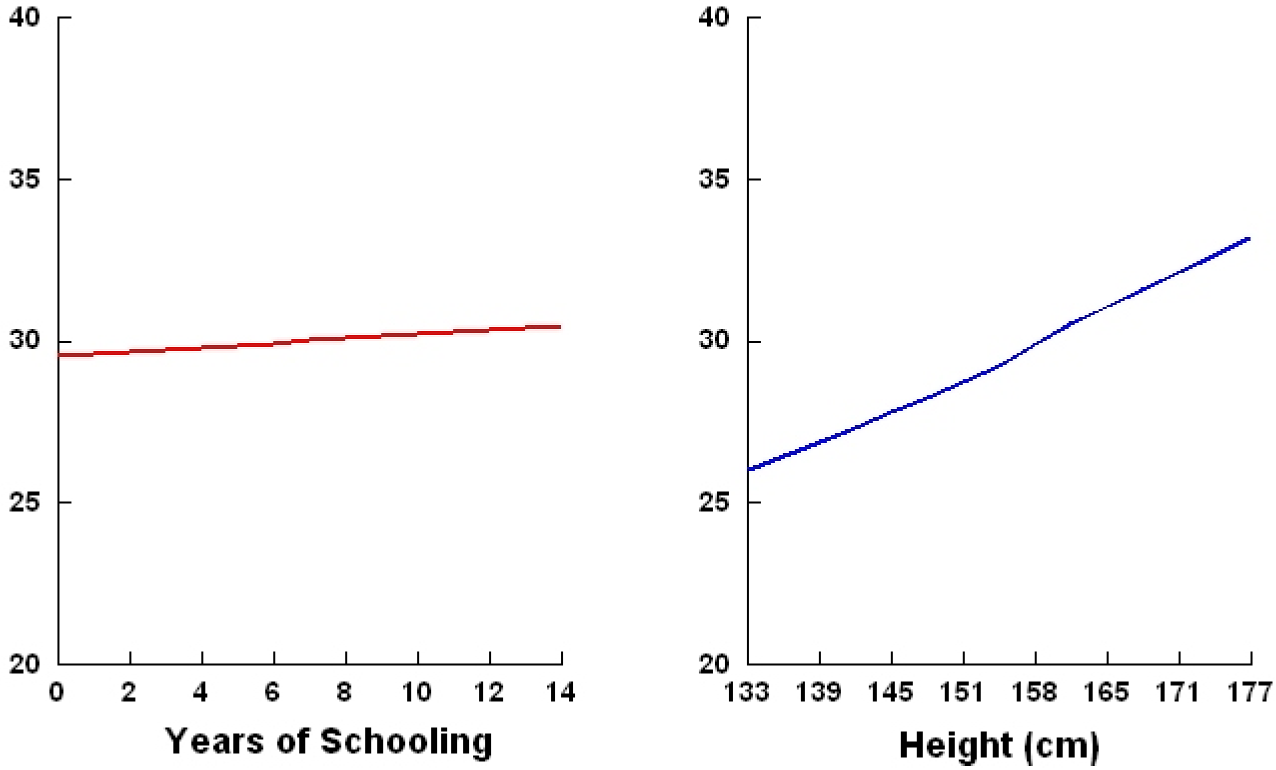
3. Adoption and use-efficacy of new contraceptive technology unrelated to schooling (Rosenzweig and Schultz, 1989)

“Contraception revolution” in 1965

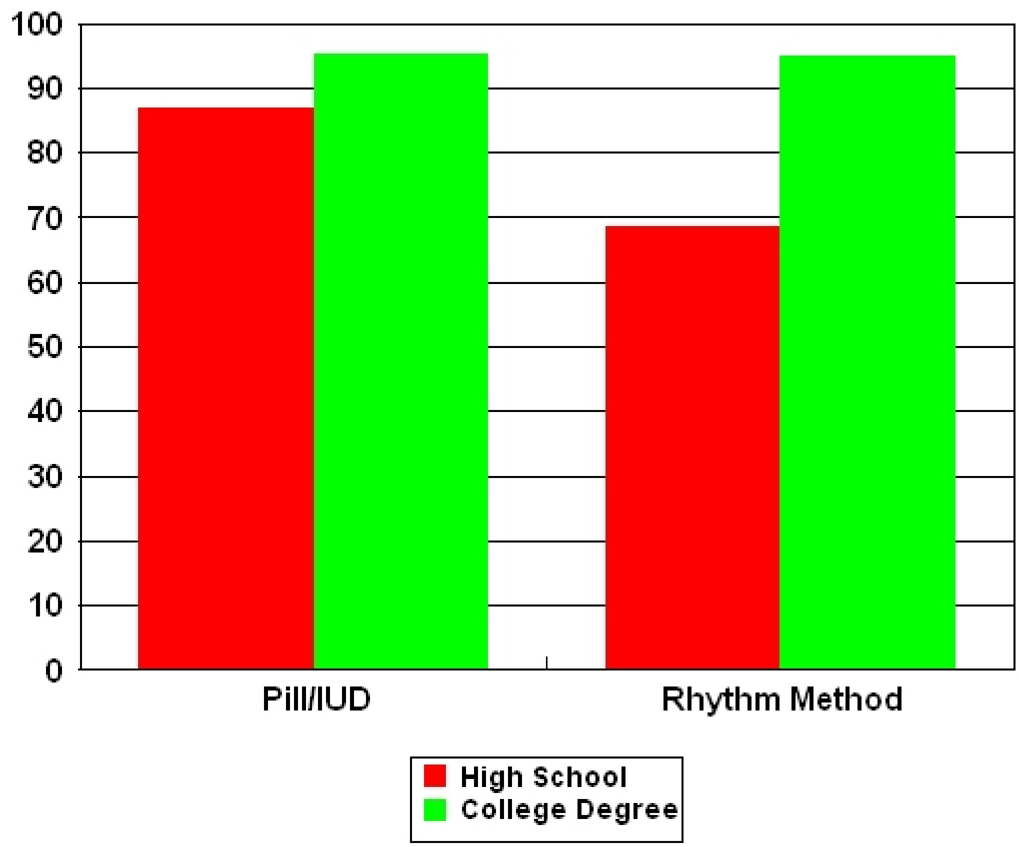
New technology *simplified* birth control

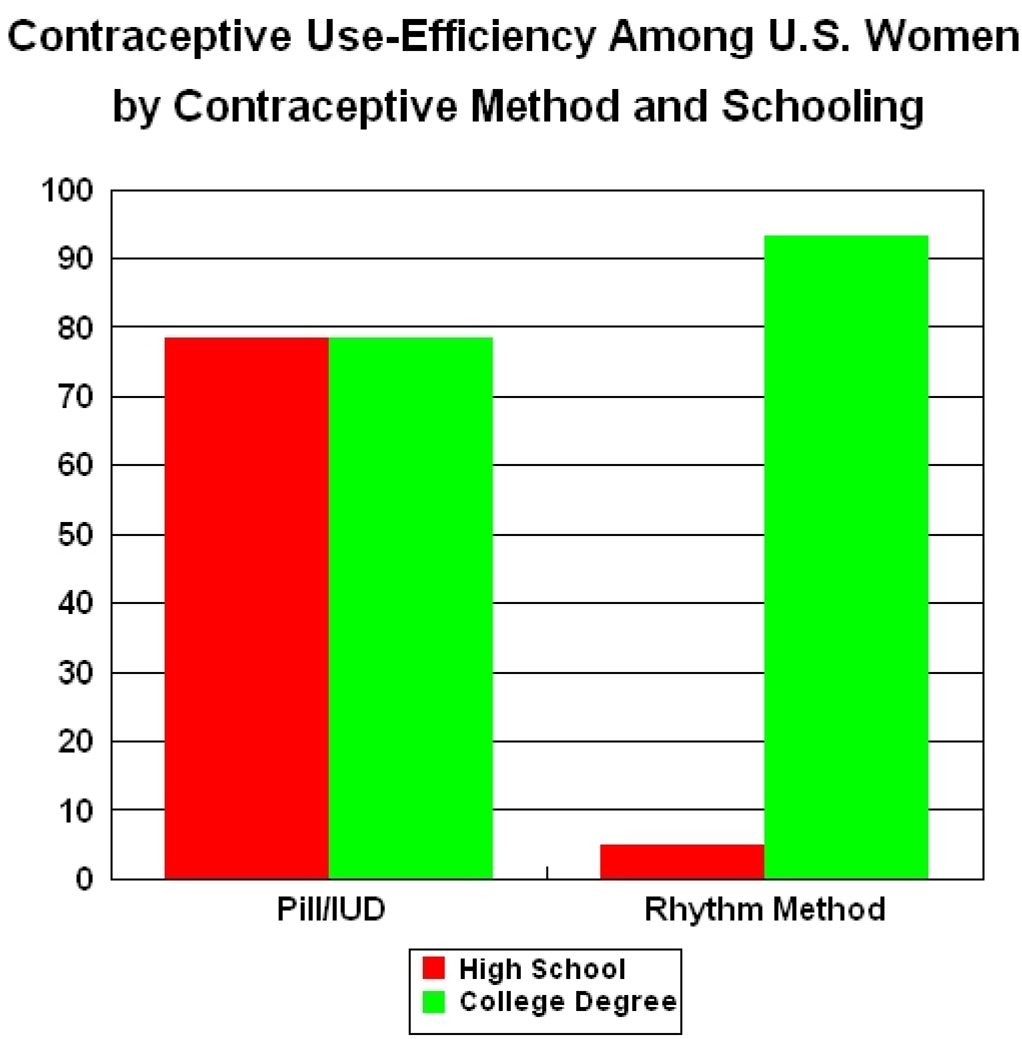
Traditional (rhythm) method was more complicated and required learning

Filippino Harvest Workers:
Effects of Schooling and Height on Piece-Rate Wages (Pesos)



% of U.S. Women with Use-Knowledge of Contraceptives, by Contraceptive Method and Schooling




Contraceptive Use-Efficiency Among U.S. Women
by Contraceptive Method and Schooling
100
90
80
70
60
50
40
30
20
10
0
Pill/IUD
Rhythm Method
High School
College Degree

LBD and Learning Externalities in Agriculture: Adopting and Using New HYV Seeds

1. The Indian "Green Revolution"

    1. Development of High-Yielding Varieties (HYV) of (hybrid) wheat, rice, corn outside of India in mid-1960's and *imported* to India.

        Policy example of market openness and market interference: substantial public investment - in local crop improvements

    2. Characteristics of "revolution"

        A. Continuous development of new seed varieties for original crops and new crops (e.g., sorghum, cotton). Continuing new challenges for farmers every year - whether and what to adopt, how to use.

        B. HYV seeds more sensitive to water, fertilizer than traditional seed varieties.

        C. HYV seeds only suitable to particular regions, given B.

        D. Because of the above, enormous growth in crop yields on average, but uneven across regions and across farmers.

A second green revolution - for Africa? - GMO's, but...

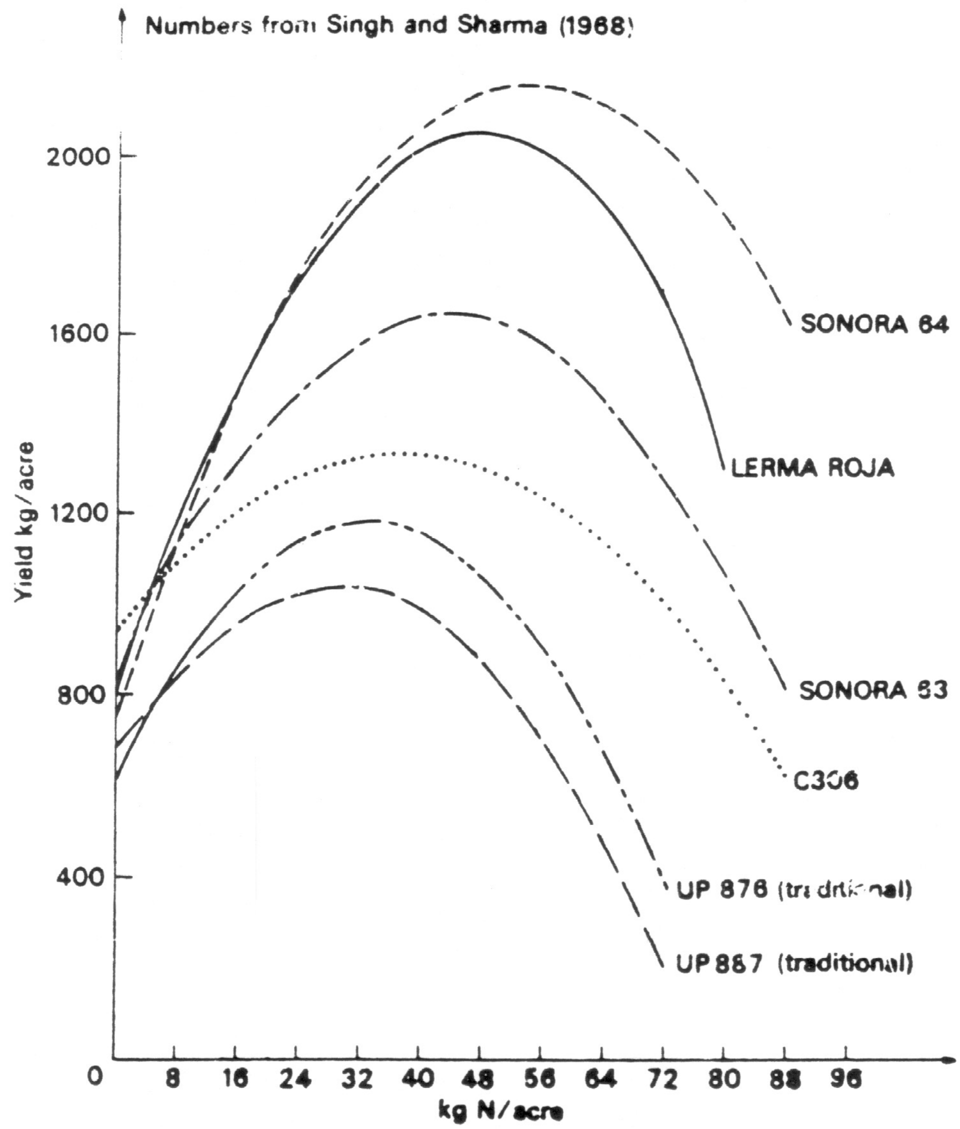
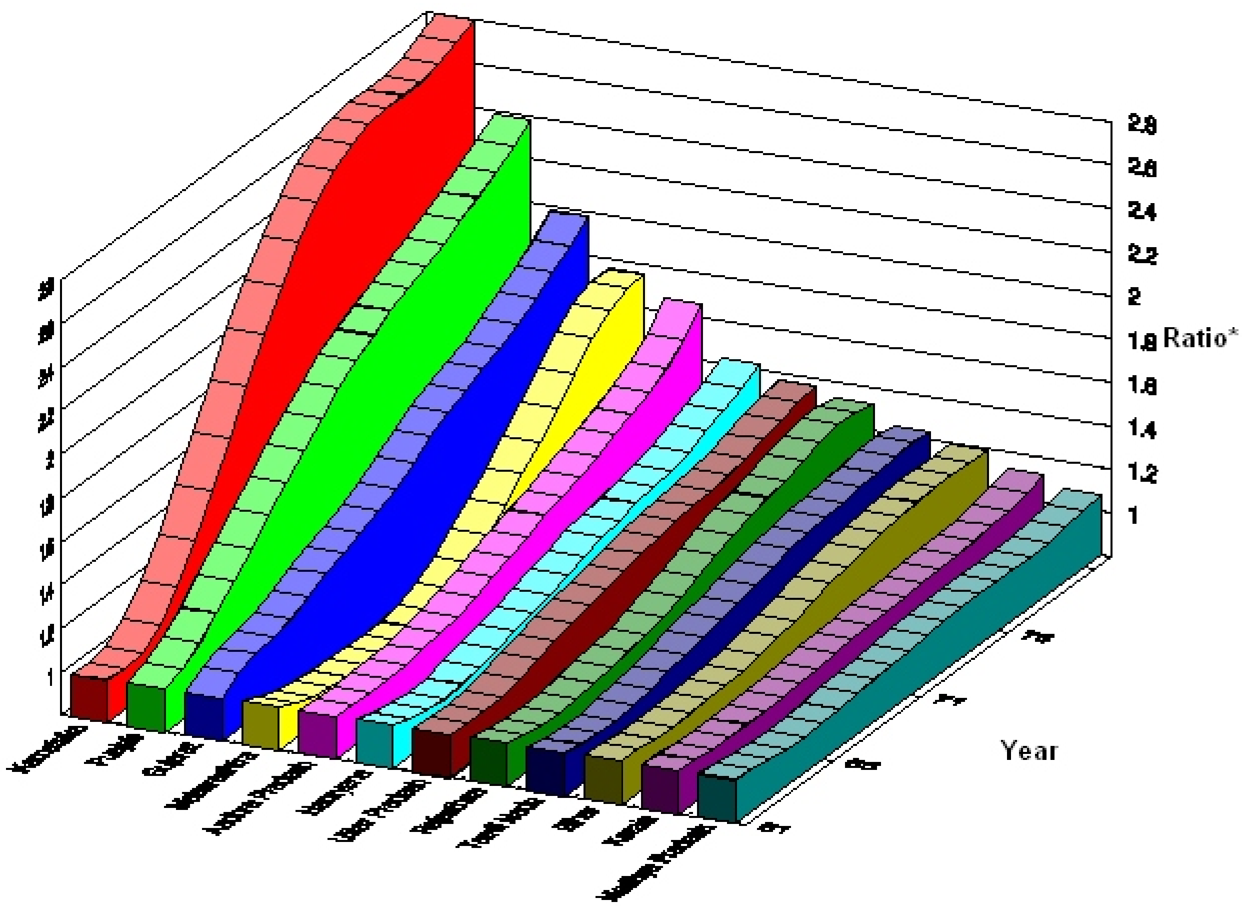


Fig. 7.1

Response of Original Mexican Varieties and Traditional (Desi) Varieties to Different Doses of Nitrogen.

Note: (i) The experiments were at U.P. Agricultural University, Pantnagar.
(ii) The curves are quadratics fitted for each case.
(iii) See § 7.1.2 for discussion.

Figure 4
HYV-Crop Productivity Growth by State:1961-81



Estimated approximation to the profit function using panel data from GR start:

1. For any farmer *i* in area *j* in the pre-growth period 0:

$$\pi_{ij0}(\ ) = \Sigma\beta_k \mathbf{A}_{kij0} + \beta_s S_{ij0} + \beta_L w_{j0} + \beta_F p_{j0} + \boldsymbol{\mu}_{ij} + \beta_\varepsilon \varepsilon_{ij0}, \tag{4}$$

where $\mathbf{A}$ = vector of farm assets, S_{ij0} = schooling

2. After the green revolution begins the structure of the profit function changes and becomes differentiated across areas (11 years later in data):

$$\pi_{ijt}(\ ) = \theta_{jt} + \Sigma(\beta_k + \alpha_k\theta_{kjjt})\mathrm{A}_{kijt} + (\beta_s + \alpha_s\theta_{jt})S_{ijt} + (\beta_L + \alpha_L\theta_{jt})w_{jt} + (\beta_F + \alpha_F\theta_{jt})p_{jt} + \boldsymbol{\mu}_{ij} + (\beta_\varepsilon + \alpha_\varepsilon\theta_{jt})\varepsilon_{ijt}, \tag{5}$$

where θ_{jt} = the area-specific level of the technology at time t ($\theta_{j0} = 0$)

α_k = the *differential* contribution of a fixed or variable factor k to profits by technology θ_{jt}

e.g., if the return to schooling ($\partial\Pi_t^m/\partial S_{ijt}$) increases with technology, ($\alpha_S > 0$)

Remove area (weather), farmer (soil, ability) fixed effects by differencing

(6) $\Delta\pi_{ijt} = \tau_{jt} + \Sigma\beta_k\Delta A_{kijt} + \Sigma\alpha_k\tau_{jt}A_{kijt} + \beta_s\Delta S_{ijt} + \Sigma\alpha_s\tau_{jt}S_{ijt} + \beta_L\Delta w_{jt} + \Sigma\alpha_L\tau_{jt}w_{jt} + \beta_F\Delta p_{jt}$

$+ \Sigma\alpha_F\tau_{jt}p_t + \beta_\varepsilon\Delta\varepsilon_{ijt}$,

where

$\Delta\pi_{ijt} = \pi_{ijt} - \pi_{ij0}$, $\tau_{jt} = \Delta\theta_{jt} = \theta_{jt}$ (because $\theta_0=0$) = area-specific technology Δ

identifies:

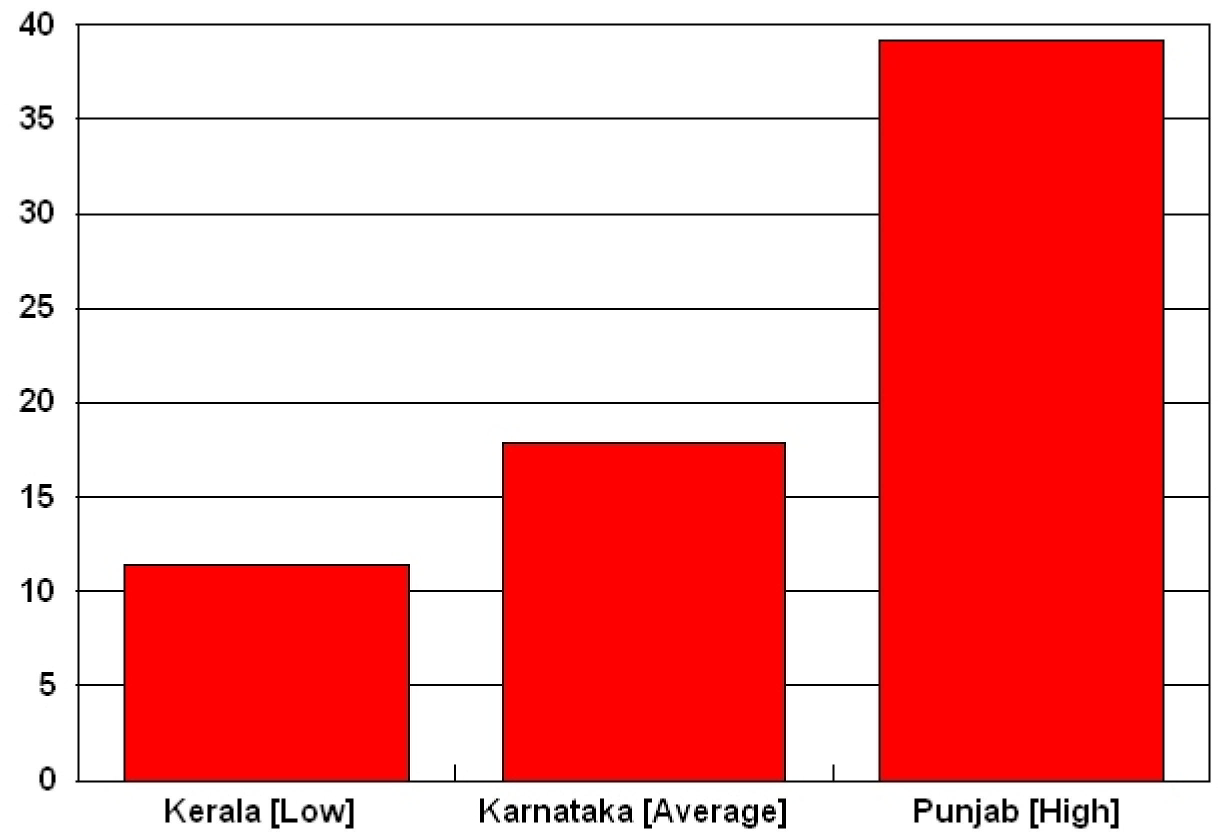
1. The pre-green revolution return to schooling: β_s

2. The change in the return to schooling after the onset of the green revolution: α_S

3. The area-specific τ_{jt}: i.e., where technological change was more and less rapid

Endogeneity of investments in farm assets and schooling accounted for.

% Differential in Farm Profits Between Schooled and Unschooled Indian Farmers in 1982, for Low, Average and Highest Technical Change States



But, why did the newly-available technology increase the returns to schooling?

Foster and Rosenzweig used panel data describing the change in farmer profits and HYV use in the first three years of the green revolution

1. Primary schooled farmers more likely to adopt - but why?

2. Higher returns to HYV among primary schooled farmers

3. Patterns consistent with learning model: more school farmers learned faster

Table 1
Probit Estimates: Determinants of HYV Adoption by 1971:
Farm Households in HYV-Using Districts

Variable	
Household Schooling:	
Primary	.524
	(8.55)
Secondary	.140
	(1.89)
Household Owned land (acres)	.0159
	(6.40)
Village Agricultural Extension	.162
	(3.04)
Village Primary Highest	.012
	(0.09)
IADP	.340
	(5.29)
Constant	-.726
	(5.57)
N	2,532

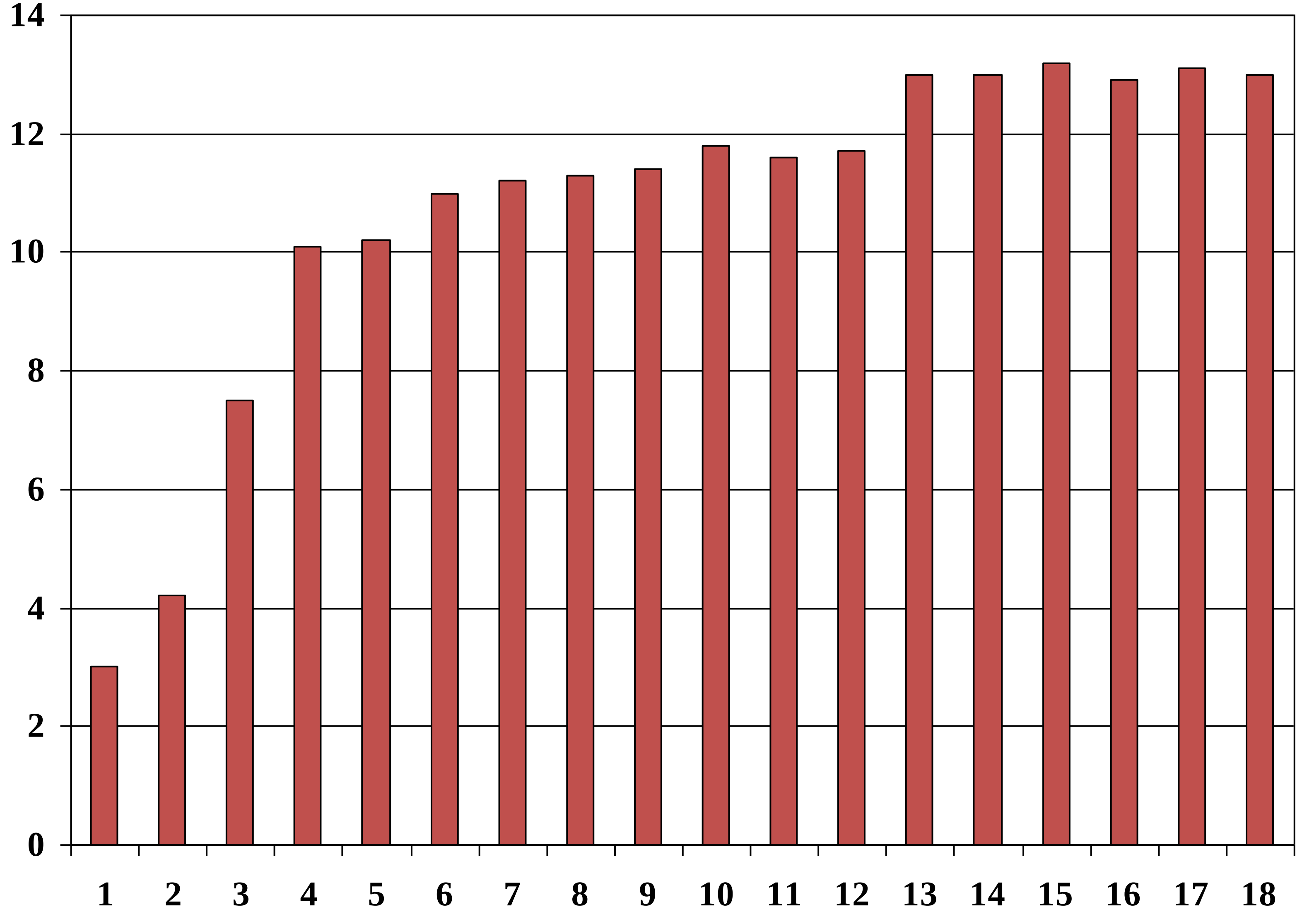
[a]Absolute values of t-ratios in parentheses.

Table 2
FE-IV Estimates: Effects of HYV Adoption on Profits (10^{-3}) per Hectare
by Prior Experience with HYV Seeds and Schooling, Initial Years of the Indian Green Revolution

Variable	(1)	(2)
Prior total HYV use (t=2) x HYV use	.00105	.00136
	(2.48)	(2.23)
Prior total HYV use (t=3) x HYV use	.000268	.000230
	(2.39)	(1.68)
Current HYV use	-.539	-.269
	(2.54)	(0.95)
Primary schooling x HYV use	.444	.0130
	(2.10)	(0.04)
Primary schooling x HYV use x prior total HYV use	-	.000240
		(2.21)
Number of observations	900	900
Number of farmers	450	450

Absolute values of asymptotic t-ratios in parentheses.

Figure A. Learning Curve for US Lawrence Company Loom Workers, 1842-55: Yards per Hour By Months on the Job (Bessen, 2003)



Microeconometric evidence on learning from others

A. Early stages of Indian green revolution

Foster and Rosenzweig (1996)

Profits rose faster the more adoption by neighboring (same village) farmers

Neighbor experience/profit trajectory same shape as own experience, consistent with learning from others

Simulations based on structural estimates indicate spillover effects are significant in affecting the trajectories of profits and HYV adoption

Evidence of strategic behavior - externalities not internalized; scope for policy intervention

Munshi (2004)

Evidence of more learning among wheat than rice farmers as information more generalizable for the former

Figure 1: Predicted Effects of Learning on Per-HectareProfitability
under Various Assumptions about Adoption and Learning

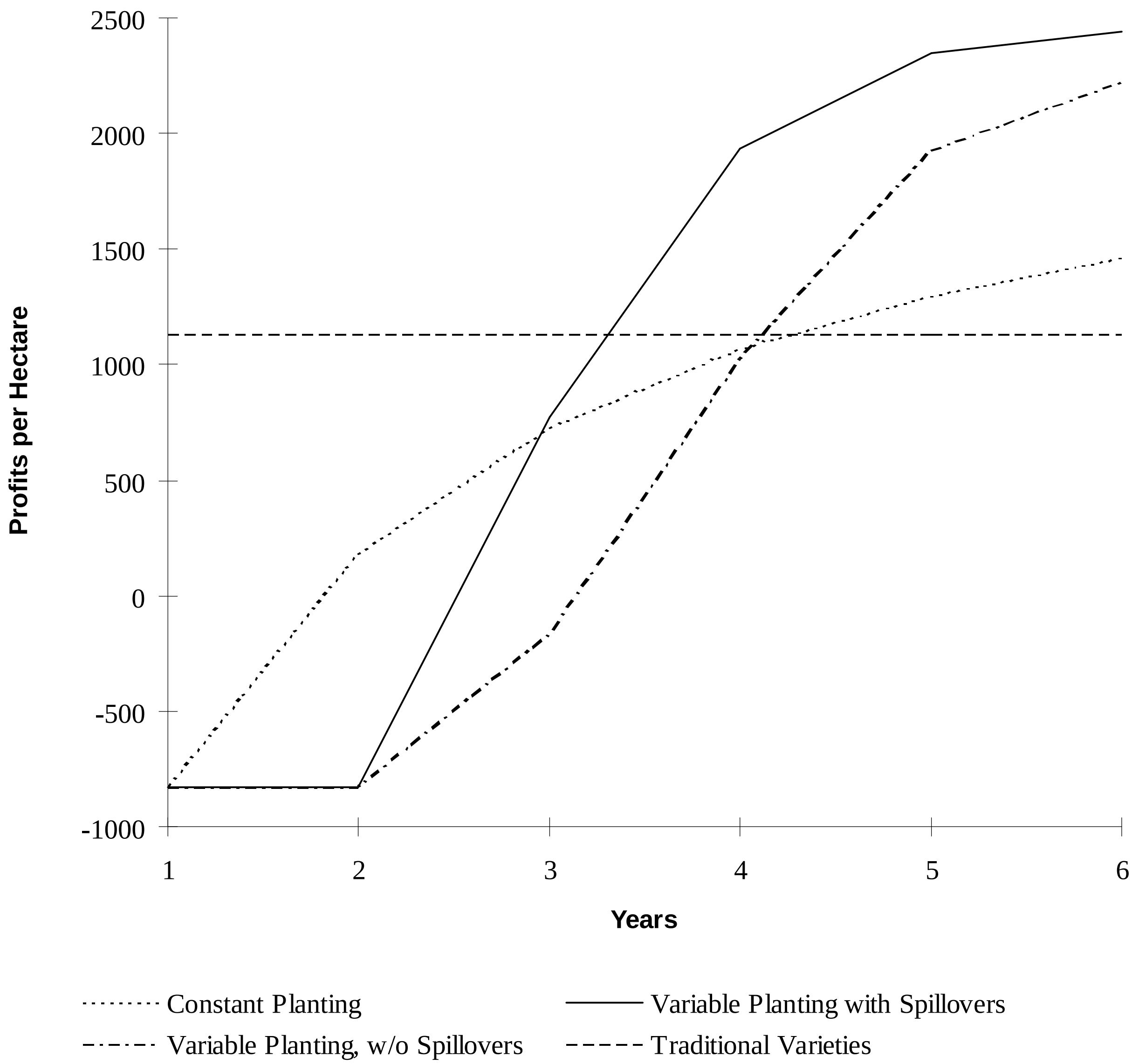
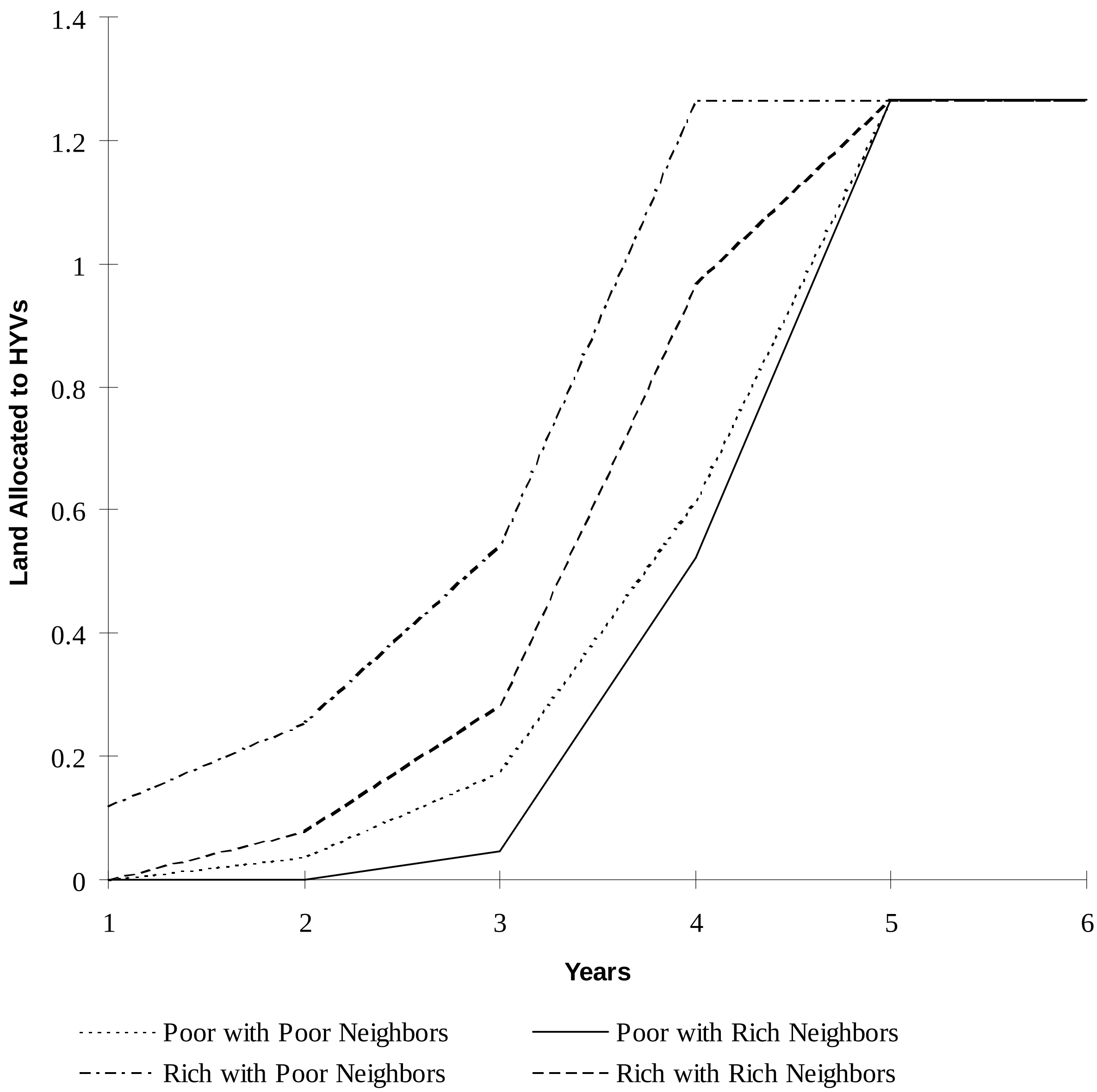


Figure 2: Predicted HYV Adoption under Various Assumptions
about the Initial Assets Held by a Farmer and His Neighbors.



B. Sunflower seed adoption (Bandeira and Rasul, 2006)

Faster adoption by the more schooled

Indirect evidence of learning from others from observed strategic behavior: Adoption was slower if more within the community adopted

C. Field experiment on bednet adoption (Dupas, 2010)

The more educated are more likely to adopt

Learning inferred: subjects more likely to adopt if someone in her group received a randomized subsidy (despite health externality, which should lower adoption)

D. Field experiment on menstrual cup adoption (Oster and Thornton, 2011)

Adoption higher if more peers offered device due to learning about best use

Subjects are students, so no schooling effects estimated

E. Fertilizer use (no new technology), Ghana farmers (Conley and Udry, 2011)

Does schooling investment respond to returns?

If the higher returns are to schooling and not just to pre-existing ability, should see a positive response with respect to schooling investment.

As Krueger and Lindahl (2001) conclude, ability bias is likely small

Do poverty, credit market failures limit responsiveness?

1. Indian Green revolution again is informative:

In areas with higher productivity growth due to new HYV seeds, increased school enrollments (Foster and Rosenzweig, 1995)

Only by cultivator households - decision makers (small wealth effect)

2. Indian reforms opening up the economy:

A. Munshi and Rosenzweig (2006): in Mumbai increase in earnings returns to knowing English in post-reform years

Dramatic rise in enrollments in expensive, English-medium schools, all groups

Change in HYV-Crop Productivity and School Enrollment in Sample Districts: 1971-82

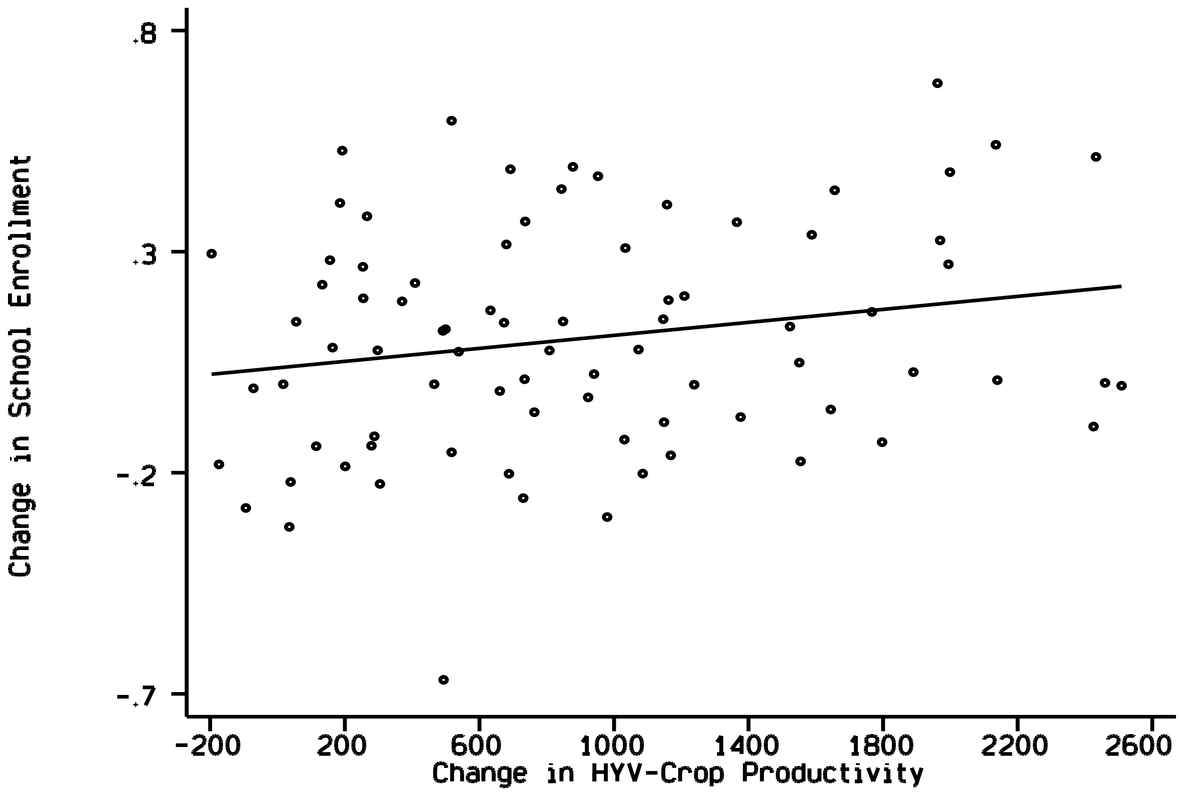


Figure 7: Rates of Return to English-medium Schooling and Years of Schooling for Men in Dadar, Bombay,by Decade, 1980-2000

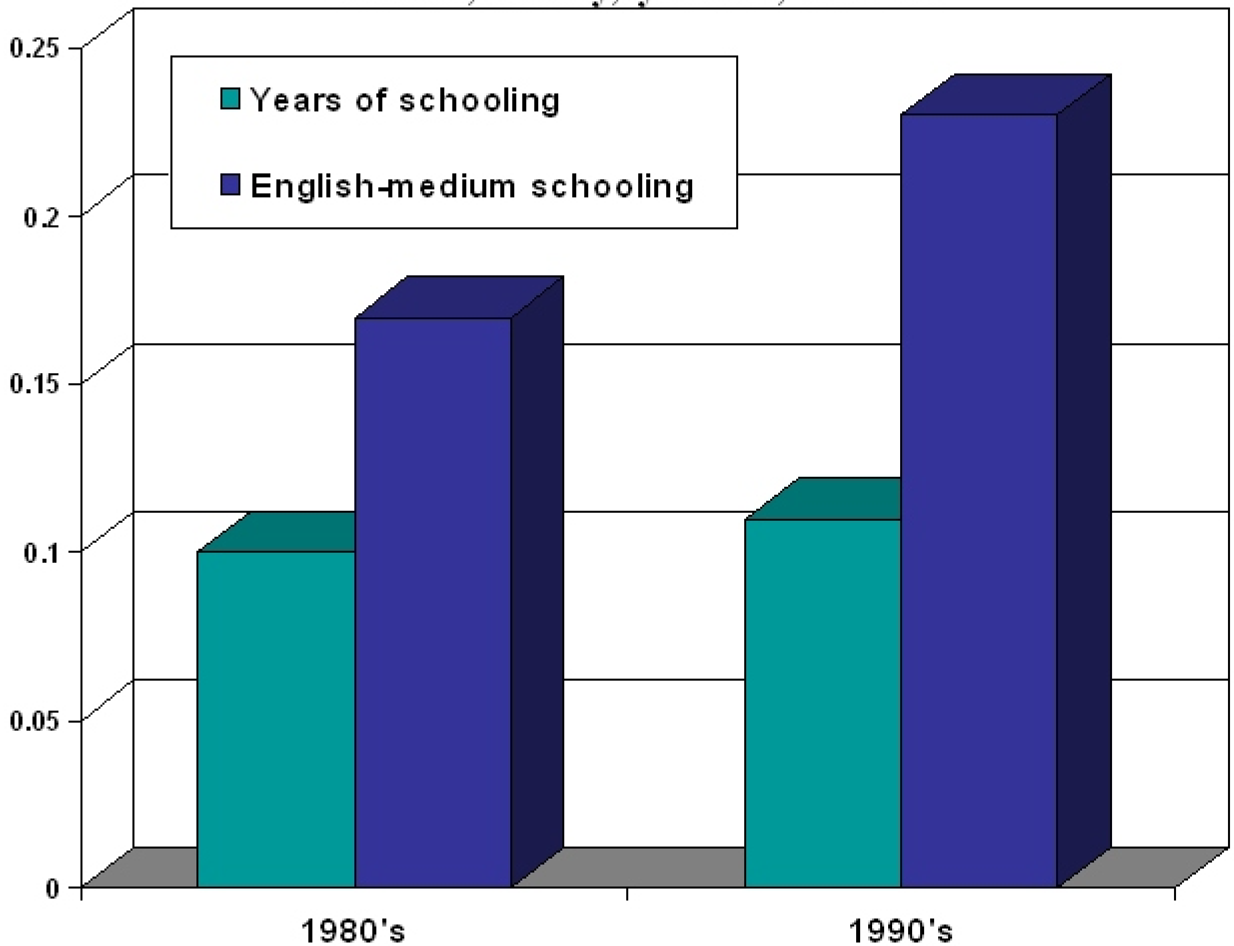


Figure 8: Rates of Return to English-medium Schooling and Years of Schooling for Women in Dadar, Bombay, by Decade, 1980-2000

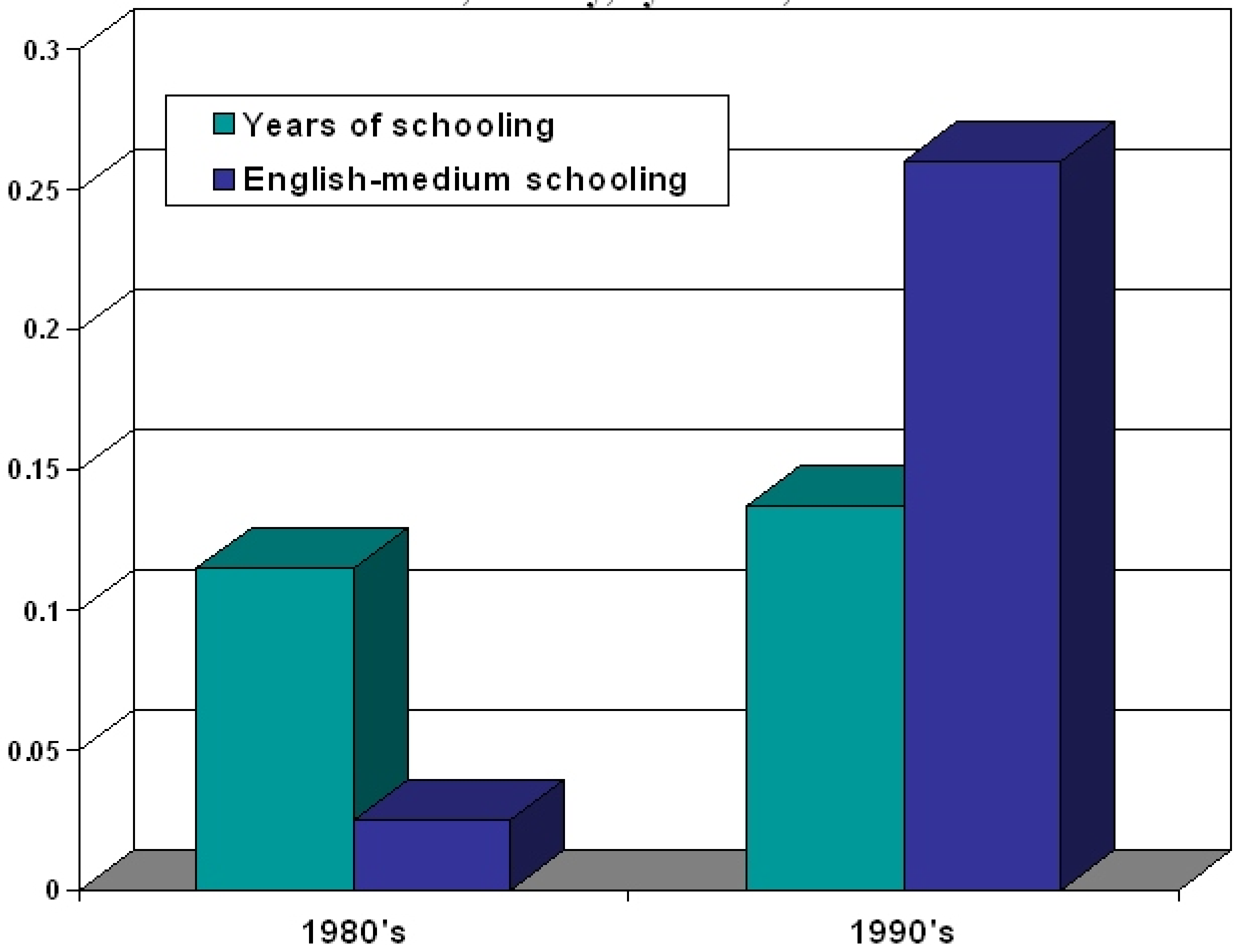
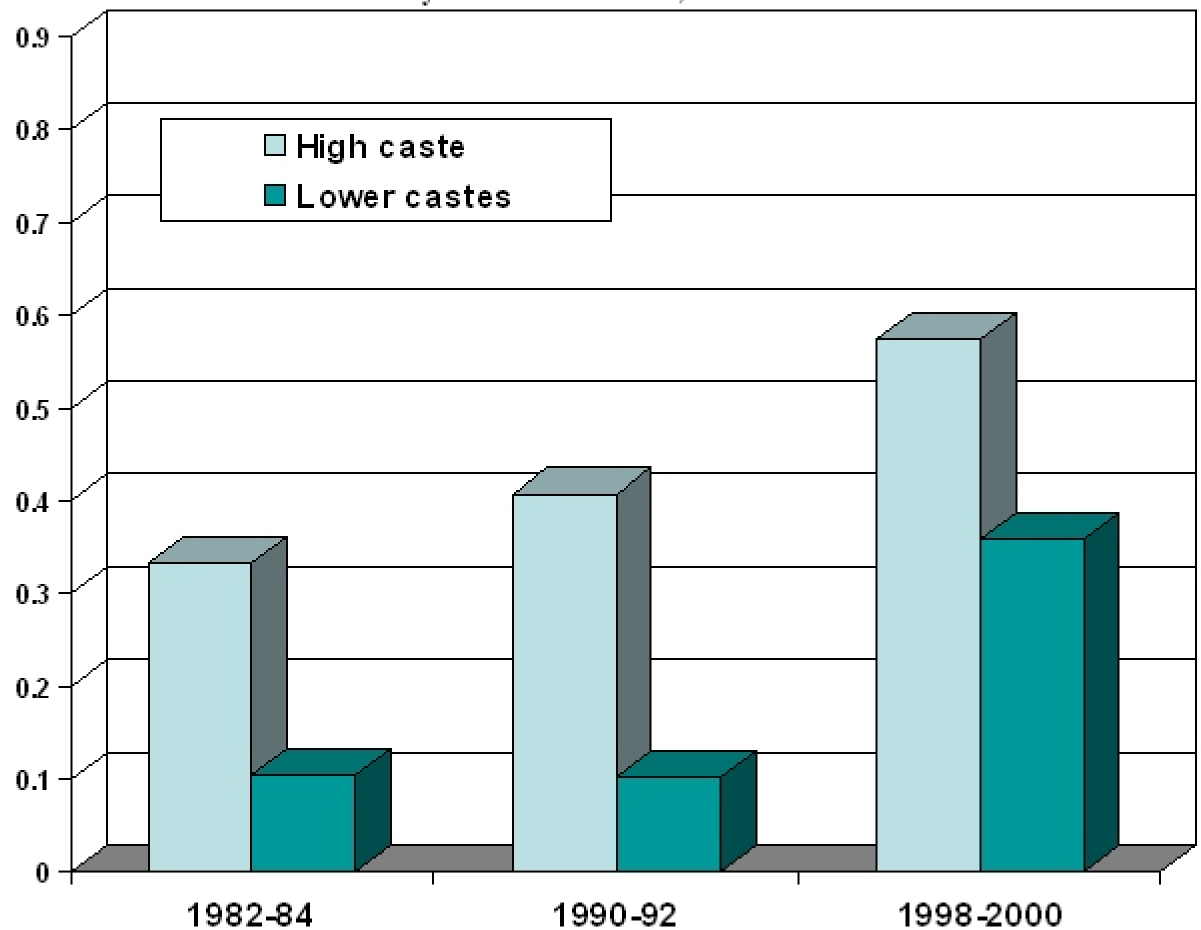


Figure 9: Fraction of Female Students Enrolling in English-medium Schools in Dadar, Bombay, by Caste and Year, 1982-2000



B. Oster and Millet (2011): local effects of initiation of ITES call centers

15% increase in enrollments in English-medium schools

3. RCT by Jensen (2010) in Dominican Republic:

Treatment: informed parents and children about returns to schooling

Treatment group completed .20 -.35 more schooling years than the control

These effects of changes in returns to schooling are comparable to those estimated for programs pushing the supply of schools in non-dynamic areas

A. Mexico *Progresa* (Schultz, 2004): increase of .66 years of schooling

Conditional (on enrollment) cash transfer program

B. Indonesia INPRES (Duflo, 2002): increase of .31 years of schooling

The largest school building program in the history of the world

Estimated return to schooling: 3.2 percent

Schooling and Fertility

In the context of unified growth models:

A key issue is not only whether increases in rates of return to schooling increase schooling, but whether the rise in schooling returns also lower fertility

For development policy:

Might also be interested in how population policies aimed at lowering fertility (family planning) affect schooling investment

There is now a large micro literature using natural, natural experiments seeking to answer the second question by examining the effects of fertility variation on investments in schooling among households

That is, they are obtaining estimates of dS/dN, where N=number of births

What do these estimates tell us about schooling return effects on fertility?

As shown in Rosenzweig and Wolpin (1980) in the context of the quality-quantity model of Becker and (1973),

$$\mathrm{d}S/\mathrm{d}N = (\mathrm{d}N/\mathrm{dp}_S)^c/(\mathrm{dN}/\mathrm{dp}_N)^c = (\mathrm{d}S/\mathrm{dp}_N)^c/(\mathrm{dN}/\mathrm{dp}_N)^c$$

The effect of adding an extra birth on schooling is the ratio of the cross-compensated *N*-*S* price effect over the fertility own price effect.

And, by symmetry,

$$\mathrm{d}N/\mathrm{d}S = (\mathrm{d}N/\mathrm{dp}_S)^c/(\mathrm{dS}/\mathrm{dp}_s)^c = (\mathrm{d}S/\mathrm{dp}_N)^c/(\mathrm{dS}/\mathrm{dp}_s)^c$$

Given that (*i*) compensated *N* and *S* cross price effects are identical and (*ii*) schooling responds positively to increases in returns (the own price effect is negative):

> knowing that (exogenous) increases in fertility lower schooling tells us that reductions in the net unit cost of schooling (an increase returns) lower fertility.

What has been found?

The first attempt to estimate the effects of fertility on schooling investment using a natural, natural experimental approach exploited the random event of twinning to see if the children in households with twins in rural India had lower schooling (Rosenzweig and Wolpin, 1980)

Found that the effect of twinning was significant and negative on all children and non-twin children

Since then, a number of studies have used variants of the twinning methodology applied to data from other, mostly more developed, countries (Caceres, 2004; Black, Devereux and Salvanes, 2005a; Angrist, Lavy and Schlosser, 2009; Qian, 2006; Li, Zhang and Zhu, 2008)

These studies have generally found a weaker fertility effect on the schooling of the *non-twin* siblings, but this weaker effect does not overturn the overall negative fertility effect on *average* per-child schooling

And the weaker fertility effect on non-twin siblings can in part be explained by reinforcing inter-child resource allocations by parents in response to the disadvantaged twins (Rosenzweig and Zhang, 2009).

Based on twins estimates on schooling and school performance outcomes in rural and urban China

A. Taking into account household resource allocations among children by parents

B. The lower endowments of twins,

Rosenzweig and Zhang estimate that the Chinese one-child policy at most increased schooling attainment by 4% and the probability of attending college by 9%

Large emerging body of evidence indicating the importance of schooling in technology adoption via learning, learning externalities and schooling responsiveness to increased rates of return

What about the evidence on increasing returns to human capital (Lucas)?

$$\Delta h = \Phi(h)$$

Pervasive cross-sectional evidence showing a positive correlation between parental schooling levels and child schooling investments

But many reasons why these associations may be spurious:

intergenerational preference linkages, genetics, etc.

Recent micro-econometric work designed to identify causal effect of parental schooling on children's human capital

Reviewed by Holmlund, Lindahl and Plug (2011)

Three methods in new literature overcoming biases:

1. Estimates of parental schooling effects from differences across mothers who are twins (Behrman and Rosenzweig, 2002; Bingley, Christensen and Jensen, 2009; Pronzato, 2009; Hegeland *et al.,* 2010)

2. Adoption studies: breaks genetic links (e.g., Plug and Vijverberg, 2003)

3. IV (e.g., intergenerational changes in school-leaving laws)

Conclusion:

Φ= 0.1 a "very small" effect, much smaller than cross-sectional estimates

Problem:

All studies from developed countries: US, France, England, Scandinavia

Negative relationship between mother's schooling and home time

Pervasive use of mother substitutes: day care, nursery schools

What about the parent schooling-child schooling relationship in low-income countries?

Behrman, Foster, Rosenzweig and Vashsihstha (1999):

Evidence from rural India showing strong Lucas relationship:

literacy of mothers efficacious in producing children's schooling

Model used incorporated the Lucas relationship, bargaining power and marriage-market selection

Identification through preponderance of evidence in early years of the green revolution in India:

Schooled women did *not* participate more in the paid labor market, so time devoted to children did not vary with schooling

Schooling of women had no effect on farm profits (they were not participating in making managerial decisions

Yet, the demand for literate wives went up significantly in high technological change areas (dowries lowered too)

Within households having two or more mothers, children of literate mothers spent more time studying and had higher school attendance

More literate mothers did not spend more on children's clothing: not a bargaining power effect

So importance of the Lucas human capital production function as a mechanism driving growth in low-income countries still an open question

Gender, Schooling and Growth (Pitt, Rosenzweig, Hassan; forthcoming; Rosenzweig and Zhang, forthcoming)

Two facts:

A. In most countries of the world the schooling level of women exceeds that of men (includes China, Bangladesh)

B. In most countries of the world, Mincer "rate of return" to schooling higher for women (Psacharopoulos and Patrinos, 2004)

C. In most countries of the world, occupational structure for women different from men

In China, the gender gap in schooling returns is increasing

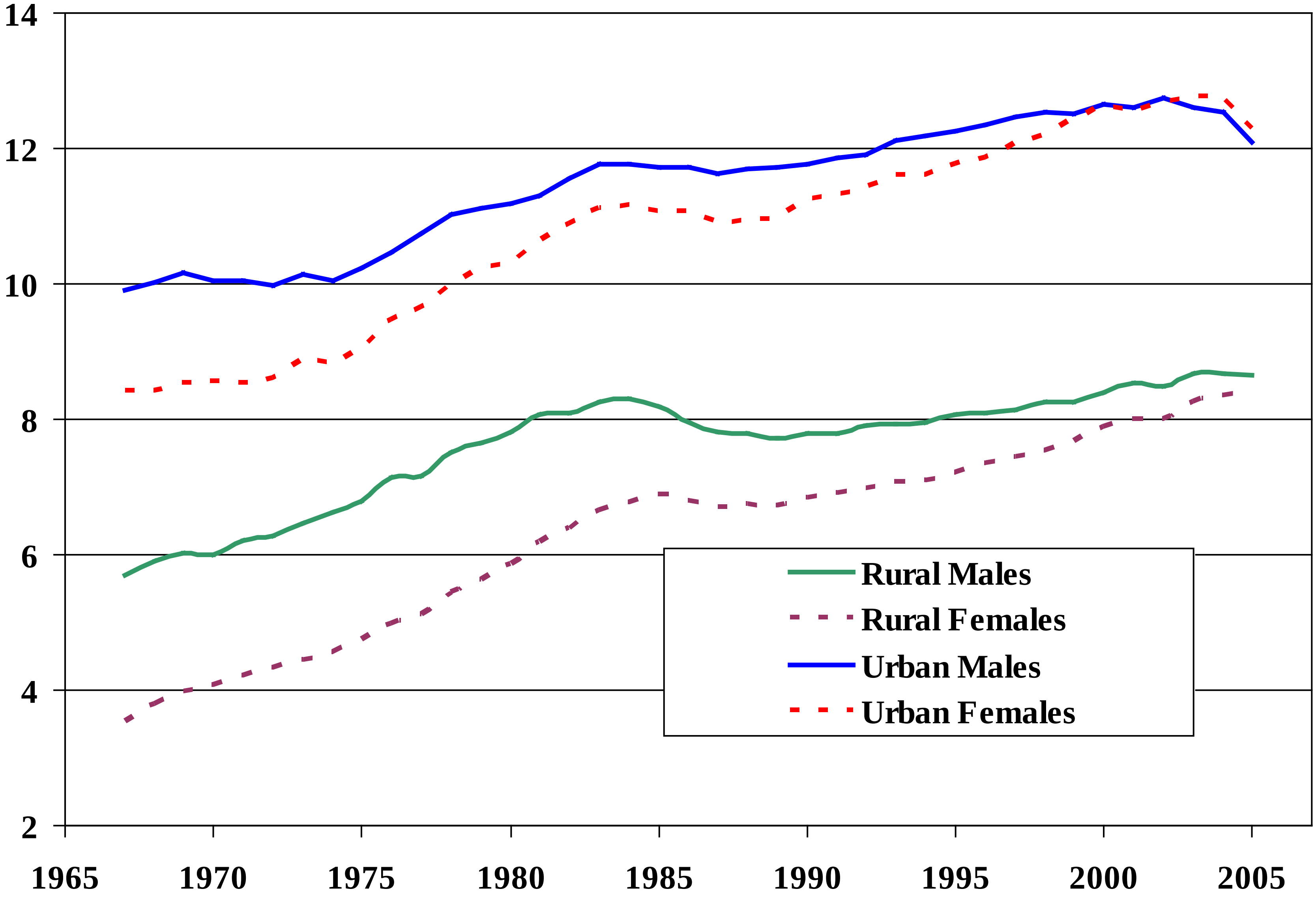
Develop and test a framework to account for these facts in which

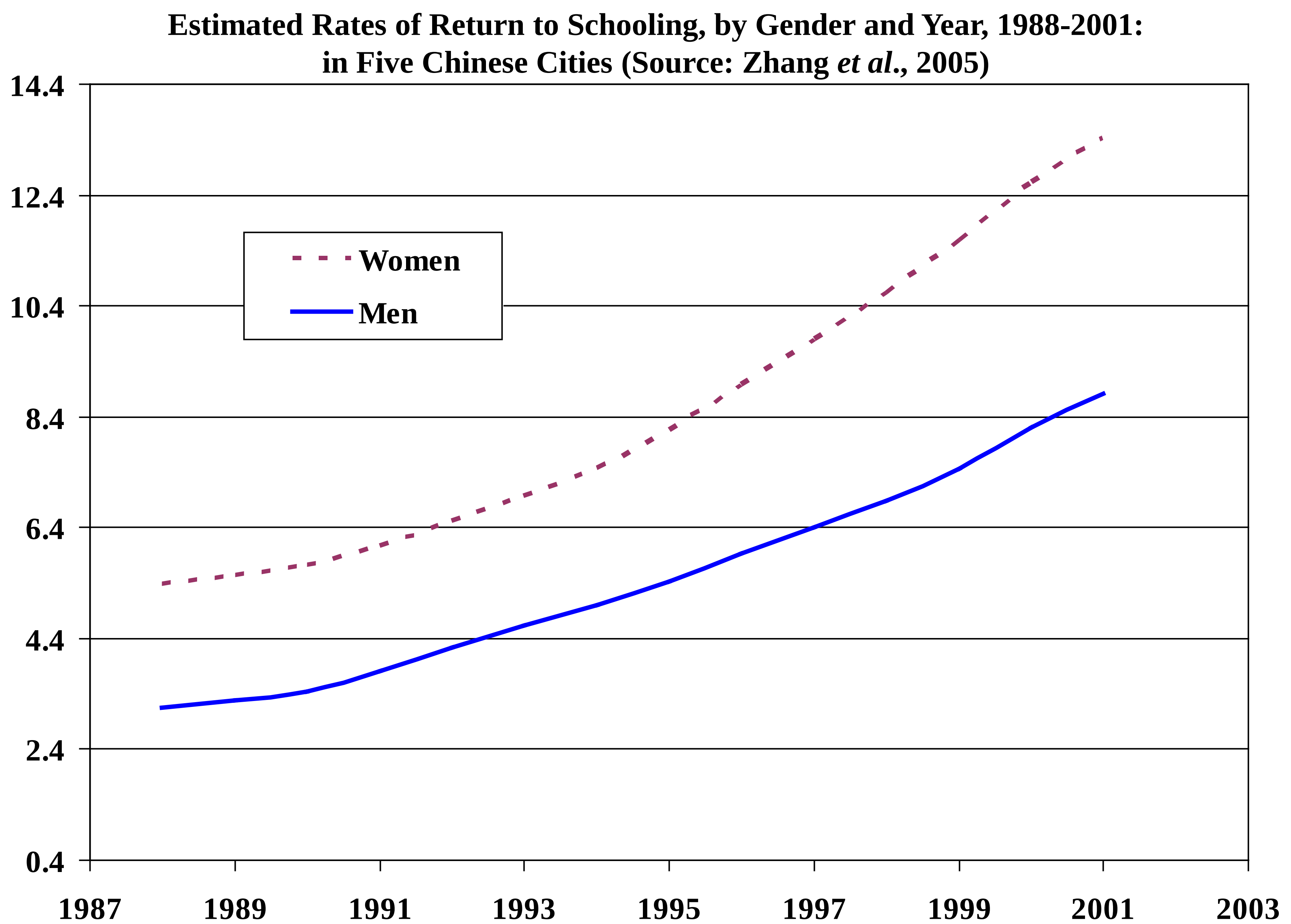
A. Investments in schooling and nutrition and occupational choice are integrated

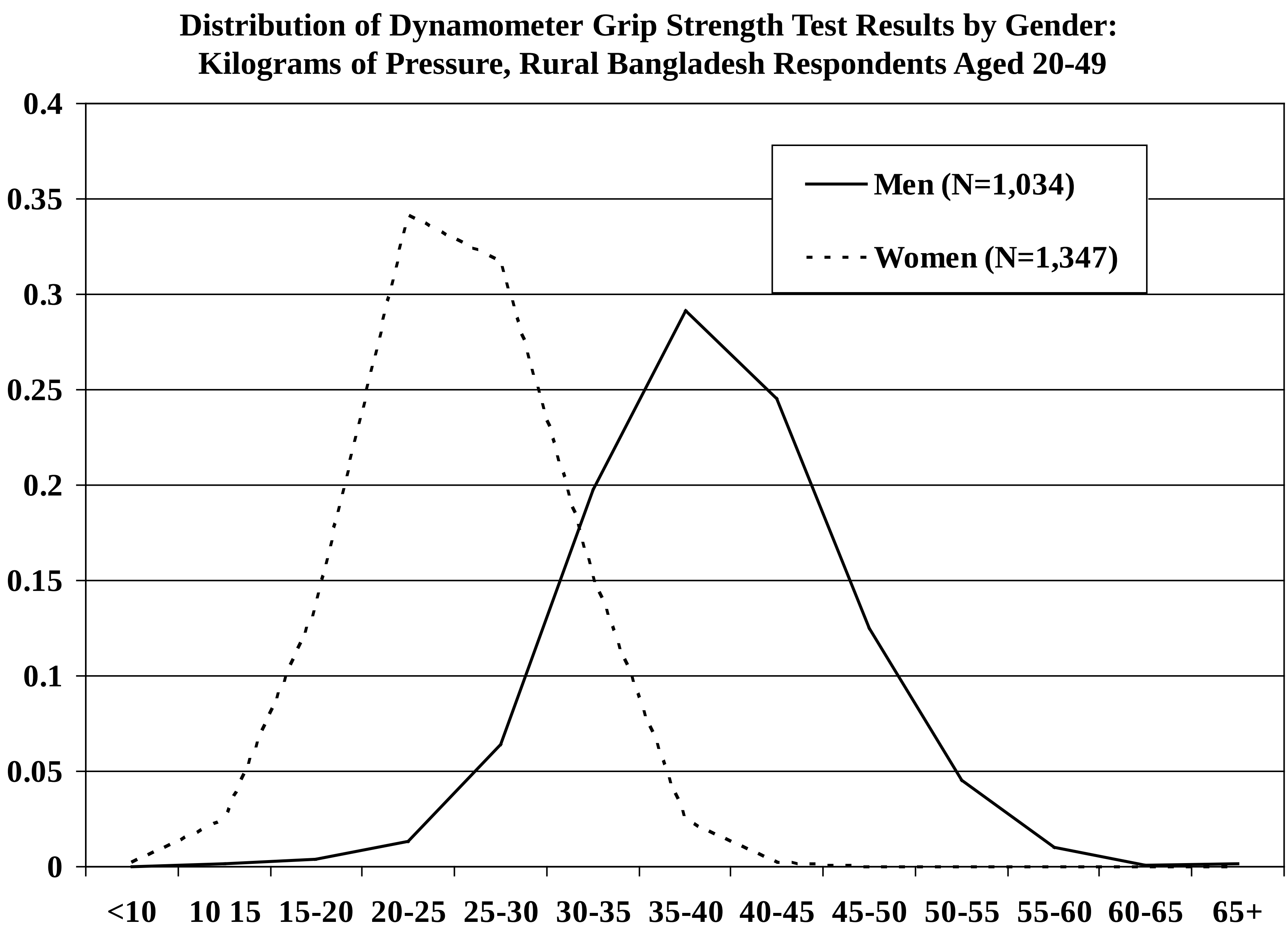
B. Workers have two salient attributes: brawn and skill (schooling)

C. Women have less brawn than men

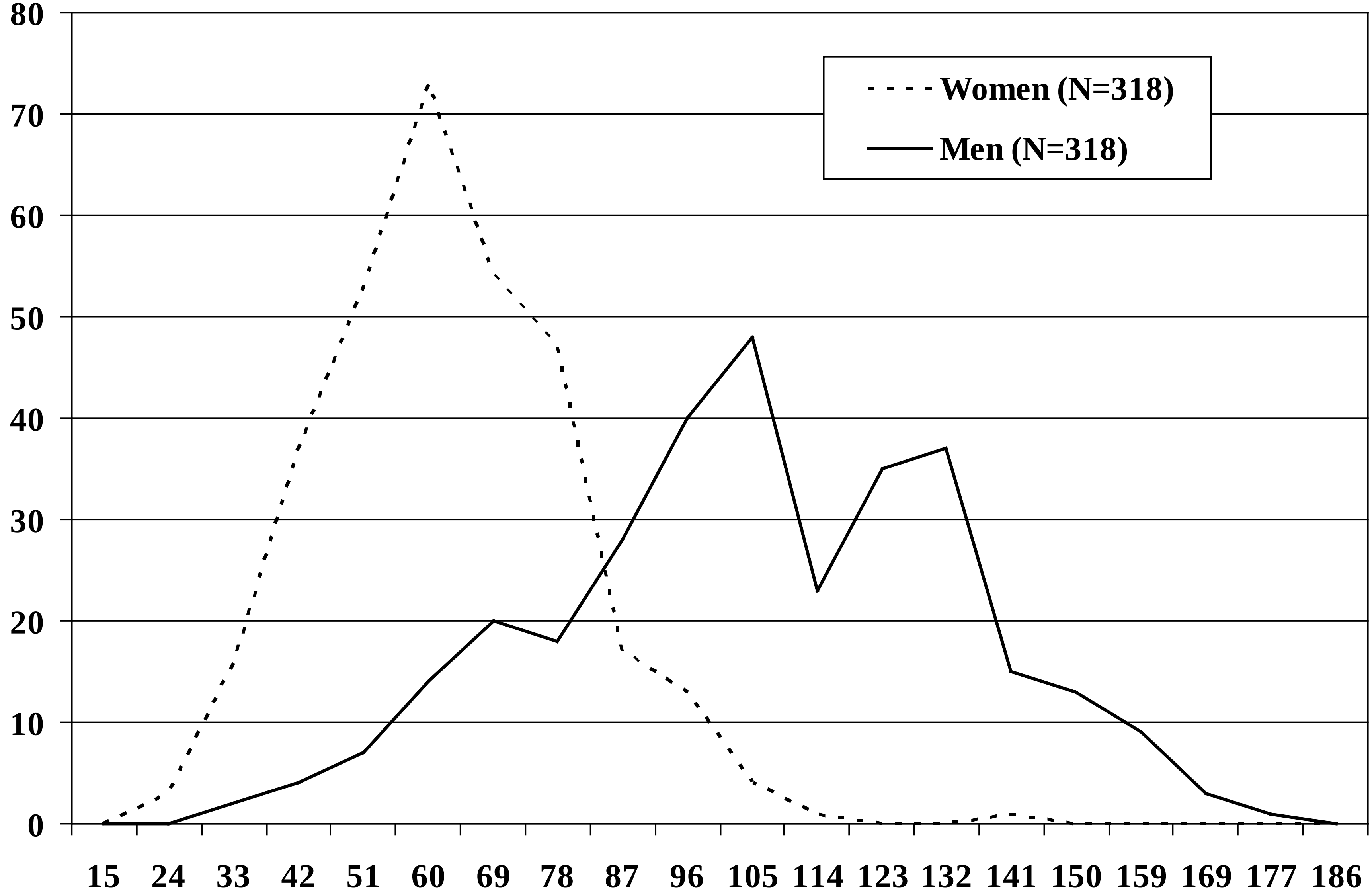
Mean Years of Schooling by Gender and Urban-Rural and Year Attained Age 22, 1967-2005
(Source: 2005 Chinese Census)




Estimated Rates of Return to Schooling, by Gender and Year, 1988-2001:
in Five Chinese Cities (Source: Zhang *et al*., 2005)
Women
Men
14.4
12.4
10.4
8.4
6.4
4.4
2.4
0.4
1987
1989
1991
1993
1995
1997
1999
2001
2003


Distribution of Dynamometer Grip Strength Test Results by Gender:
Kilograms of Pressure, Rural Bangladesh Respondents Aged 20-49
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Men (N=1,034)
Women (N=1,347)
<10
10 15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
50-55
55-60
60-65
65+

Distribution of Dynamometer Grip Strength Test Results by Gender (Mathiowetz *et. al* (1985)): Pounds of Pressure, U.S. Respondents Aged 20-94



Male Occupational Distributions in Bangladesh in 2004, by Rural-Urban

Occupation/ Population	Rural	Urban
Men		
Farmer, agricultural laborer, fisherman	49.4	9.7
Unskilled laborer (rickshaw puller, brick breaking, etc.)	12.0	14.8
Factory worker or blue-collar service	3.3	7.5
Semi-skilled laborer (carpenter, mason, bus/taxi driver)	9.8	22.4
Professional (teacher, doctor, lawyer)	2.4	5.2
Business	16.4	31.3
Other	0.6	0.4
Not working	5.8	8.7

Source: Bangladesh: Demographic and Health Survey, 2004

Female Occupational Distributions in Bangladesh in 2004, by Rural-Urban

Occupation/ Population	Rural	Urban
Women		
Agricultural worker	1.2	0.4
Home-based manufacturing	3.7	3.1
Unskilled laborer (construction, brick breaking, etc.)	2.7	2.4
Poultry raising, cattle raising, trading	7.8	3.5
Domestic labor	2.0	5.8
Semi-skilled service (tailor, etc.)	3.0	6.4
Professional (teacher, doctor, lawyer)	0.5	1.7
Business	1.7	2.3
Other	0.9	1.8
Not working	76.3	72.6

Source: Bangladesh: Demographic and Health Survey, 2004

Economy described by Roy model:

A. Each worker provides a bundle of skill H and brawn B to perform tasks.

B. There is a continuum of tasks indexed by i.

C. There is a task function for each activity i.

If the task function is Cobb-Douglas (any crs function will do), the wage function is:

(1) $$W = \pi(i)v(i)(\kappa H)^{\alpha(i)}B^{(1-\alpha(i))},$$

where $\pi(i)$ = the equilibrium price of the output of task i,
$v(i)$ = a task-specific productivity parameter,
κ = is a scalar that converts H into units of brawn,
$\alpha(i)$ = skill intensity of task/occupation i,

if order tasks by skill intensity, so $i'>i$, then $\alpha(i') > \alpha(i)$

Then, for a worker with attributes B and H, (1) is maximized when occupation i is chosen such that

(2) $$\log(\kappa H/B) = -(\pi_i + v_i)/\alpha_i\pi(i)v(i) \qquad \text{comparative advantage}$$

Show in model in which schooling is obtained optimally:

> women will always have a comparative advantage in skill relative to men and select occupations that are skill intensive - occupations in which schooling is more productive

If development is characterized by shift to more skill-intensive occupations, at least in the short run, the male-female division of labor will increase and average “returns” for women will grow relative to men as the division of labor increases

Tested on rural Bangladesh panel data:

A. Males born with greater body mass completed less schooling years

B. Males born with greater body mass chose more energy-intensive occupations

C. Women with greater body mass slightly more schooling

(Consistent with body mass and strength weak for women)

Estimated the task function from data from rural Bangladesh households:

- Used detailed FAO measures of occupation-specific energy expenditures to characterize occupation
- Estimation procedure allows occupation and schooling to be chosen optimally
- Estimates:
  - In 3/4 of activities occupied by men, the returns to schooling are not positive, returns to brawn high;
  - In most of the occupations in which women are represented, opposite

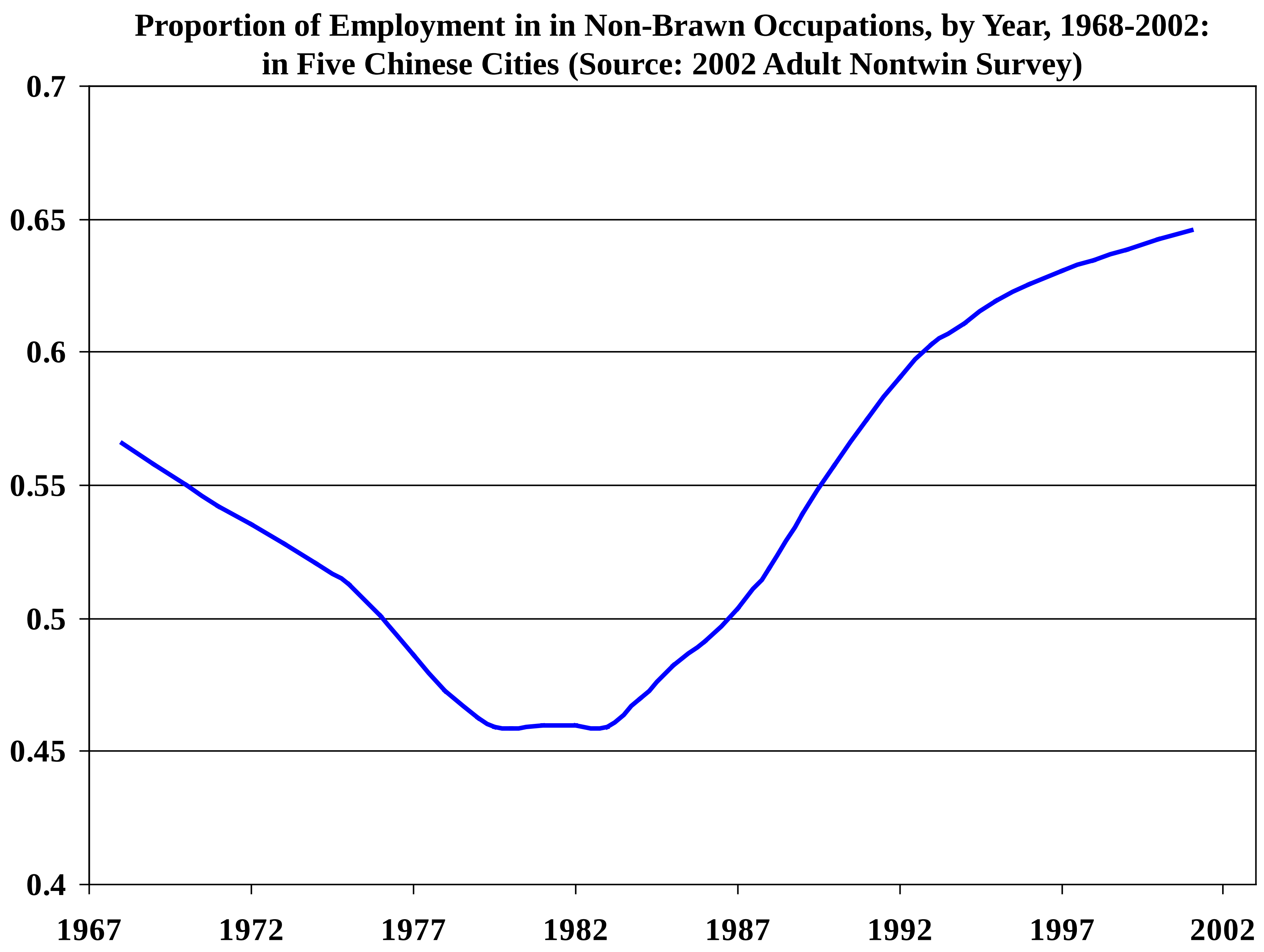
China:

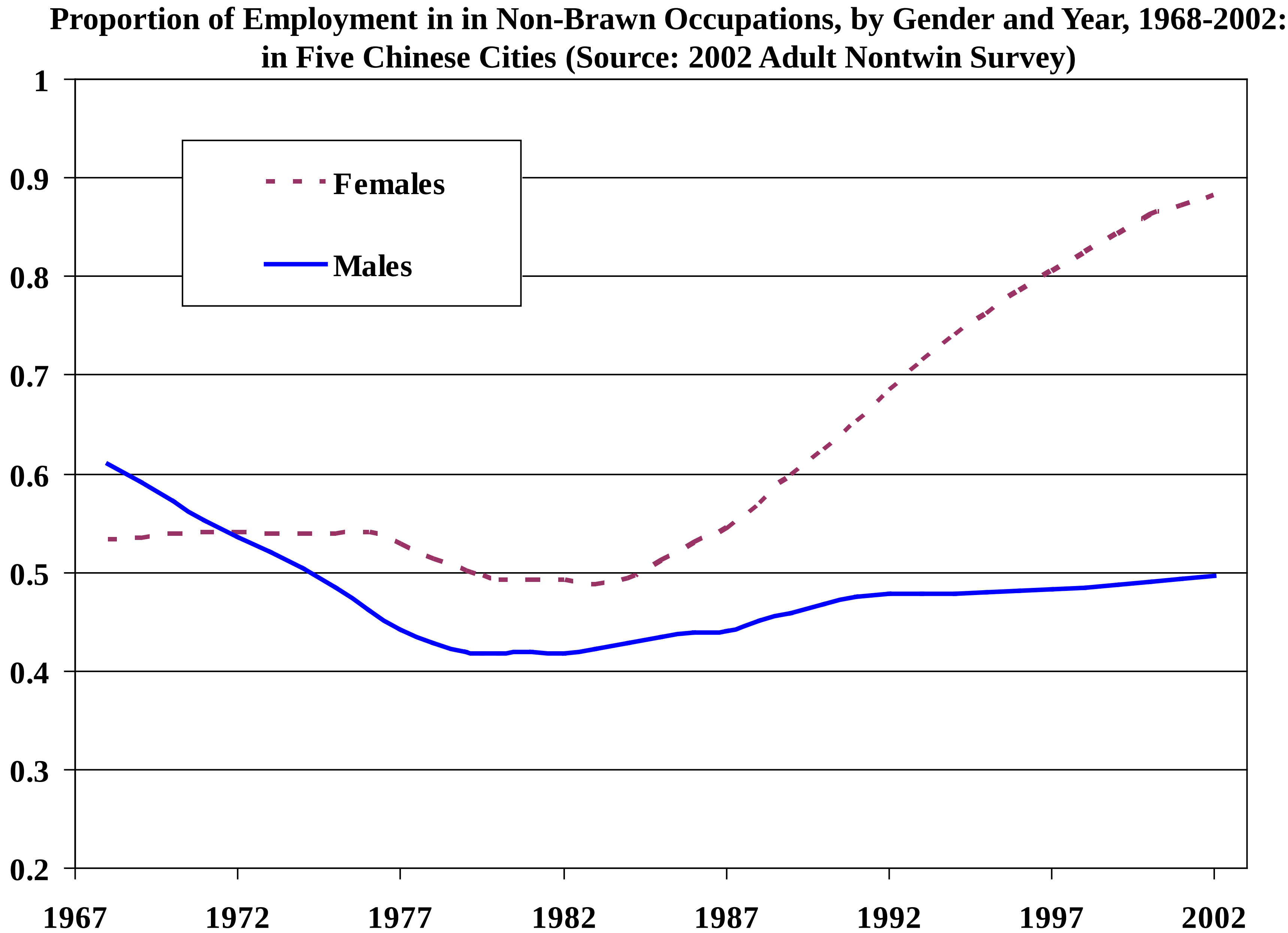
- Evidence of occupations becoming less brawn-intensive post-Mao
- Evidence of increasing occupational division of labor by gender
- Consistent with short-run rise in “returns” to schooling of women versus men

Task Function Estimates for Bangladesh, by Gender
Occupation-Specific (Log) Wage Function Estimates: Adults Aged 20-49 in 2001-2

Gender	Male			Female		
Estimation procedure	GLS[a]	GLLAM[a]	GLLAM-IV[b]	GLS[a]	GLLAM[a]	GLLAM-IV[b]
Schooling	.0409 (11.6)	.0417 (10.1)	.334 (2.75)	.0487 (2.38)	.0467 (2.41)	1.14 (2.05)
Schooling x occupation energy expenditure	-	-	-.00256 (2.87)	-	-	-.007 (2.03)
BMI	-	.0765 (0.84)	-1.46 (2.34)	-	.0895 (0.22)	-4.53 (1.28)
BMI x occupation energy expenditure	-	-	.0115 (2.85)	-	-	.0254 (1.52)
Age x occupation energy expenditure	-	-	.000401 (1.16)	-	-	.00204 (1.09)
λ	-	-	-	11.7 (1.46)	12.7 (1.49)	10.3 (0.78)
N	1,094	1,094	1,094	79	79	79

Source: NSRB 2001-2. [b]Bootstrapped *t*-ratios in parentheses in column.


Proportion of Employment in in Non-Brawn Occupations, by Year, 1968-2002:
in Five Chinese Cities (Source: 2002 Adult Nontwin Survey)
0.7
0.65
0.6
0.55
0.5
0.45
0.4
1967
1972
1977
1982
1987
1992
1997
2002



Proportion of Employment in in Non-Brawn Occupations, by Gender and Year, 1968-2002:
in Five Chinese Cities (Source: 2002 Adult Nontwin Survey)
Females
Males
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
1967
1972
1977
1982
1987
1992
1997
2002

Issues not addressed here for which there is rigorous micro research:

A. Health and schooling

Michael Kremer lecture

B. Credit constraints as a barrier to schooling

Rob Townsend lecture

Caution: interpreting responses to interventions by income or wealth:

Wealth reflects ability and preferences (intergenerationaly correlated), and market completeness

C. Improvements in schools

Large and growing literature on tutoring, inputs, tracking, class size, vouchers, teacher incentives; lecture by Esther Duflo

For all interventions, the returns clearly depend on the role of schooling in growth

Open questions

A. Schooling and the production of original ideas, inventions, innovations:

New ideas, innovations critical to growth: what is the evidence on role of schooling? (Edison, Watt, Whitney, Shockley, Gates, Jobs)

Does curriculum matter for spurring creativity?

Existing evidence on what goes on in school evaluated in terms of knowledge (achievement tests). Does this matter for productivity, innovation (Heckman *et al.*: non-cognitive skill) ?

Does the organization of schools matter: what enhances learning-from-others, interactions between people? (departments, institutes)

B. Schooling and entrepreneurship: can entrepreneurs be trained?

C. Schooling and leadership: are better leaders more schooled? Can leaders be trained?

(Munshi and Rosenzweig (2010): more competent elected members of Indian village *panchayats* not more schooled)