BREAD IGC Lectures on Education

education $\neq$ schooling years

We will have many lectures on schools producing education.

But, years in school is an important indicator of education.

In my lectures, we will look at:

1. The productivity of education, with schooling years as a proxy: how to measure? what determines it?

2. Some of the barriers to schooling investment:

   low productivity, income, health, family size.

Some facts about schooling

A. Low schooling is a major feature of low income countries.

B. Strong correlation between per-capita GDP and schooling.

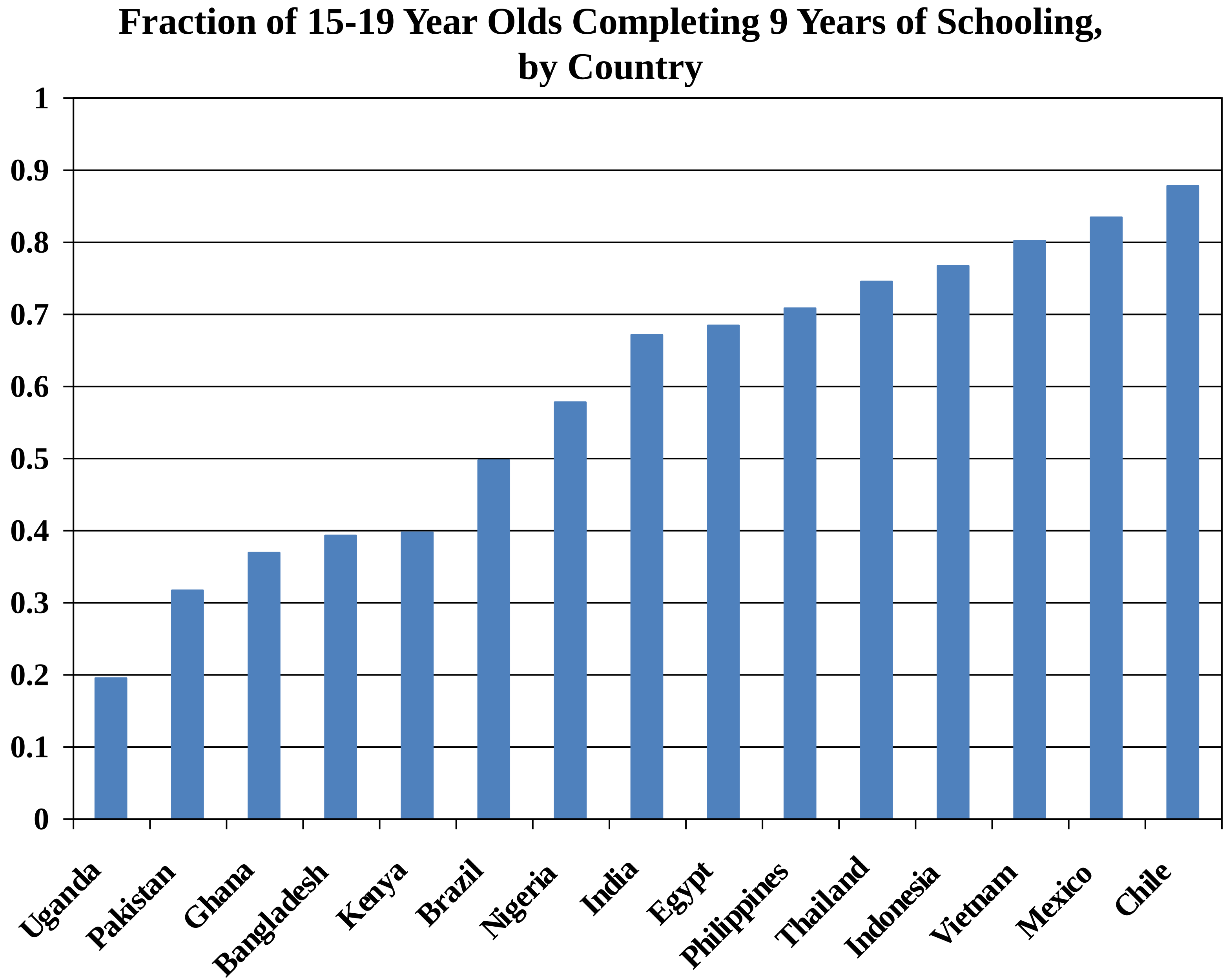
Low schooling causes underdevelopment?

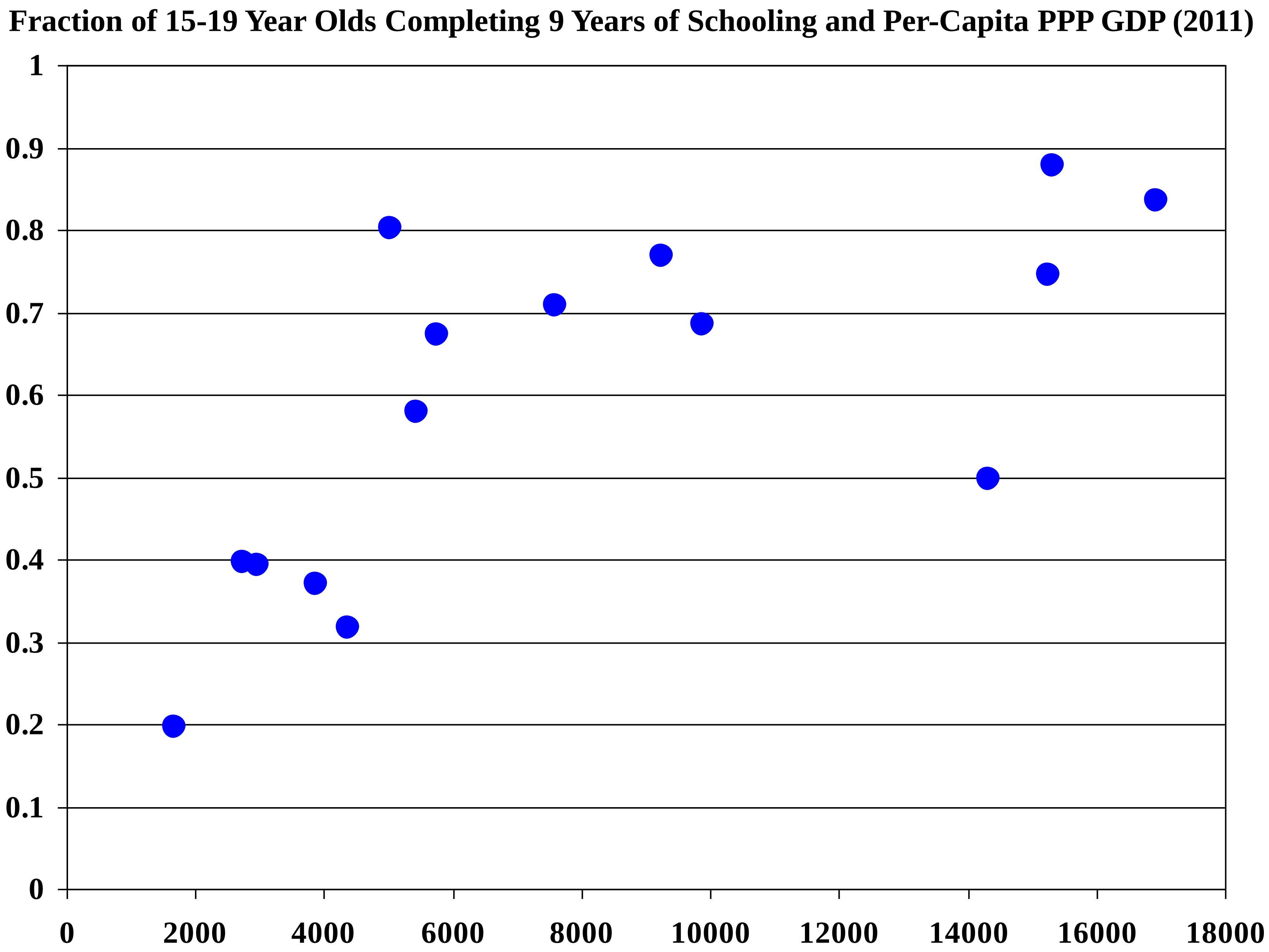
Underdevelopment causes low schooling?

income effect? low productivity? bad schools?

C. In most countries of the world, including low-income countries

Schooling of women exceeds that of men. Why?


Fraction of 15-19 Year Olds Completing 9 Years of Schooling,
by Country
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Uganda
Pakistan
Ghana
Bangladesh
Kenya
Brazil
Nigeria
India
Egypt
Philippines
Thailand
Indonesia
Vietnam
Mexico
Chile


Fraction of 15-19 Year Olds Completing 9 Years of Schooling and Per-Capita PPP GDP (2011)
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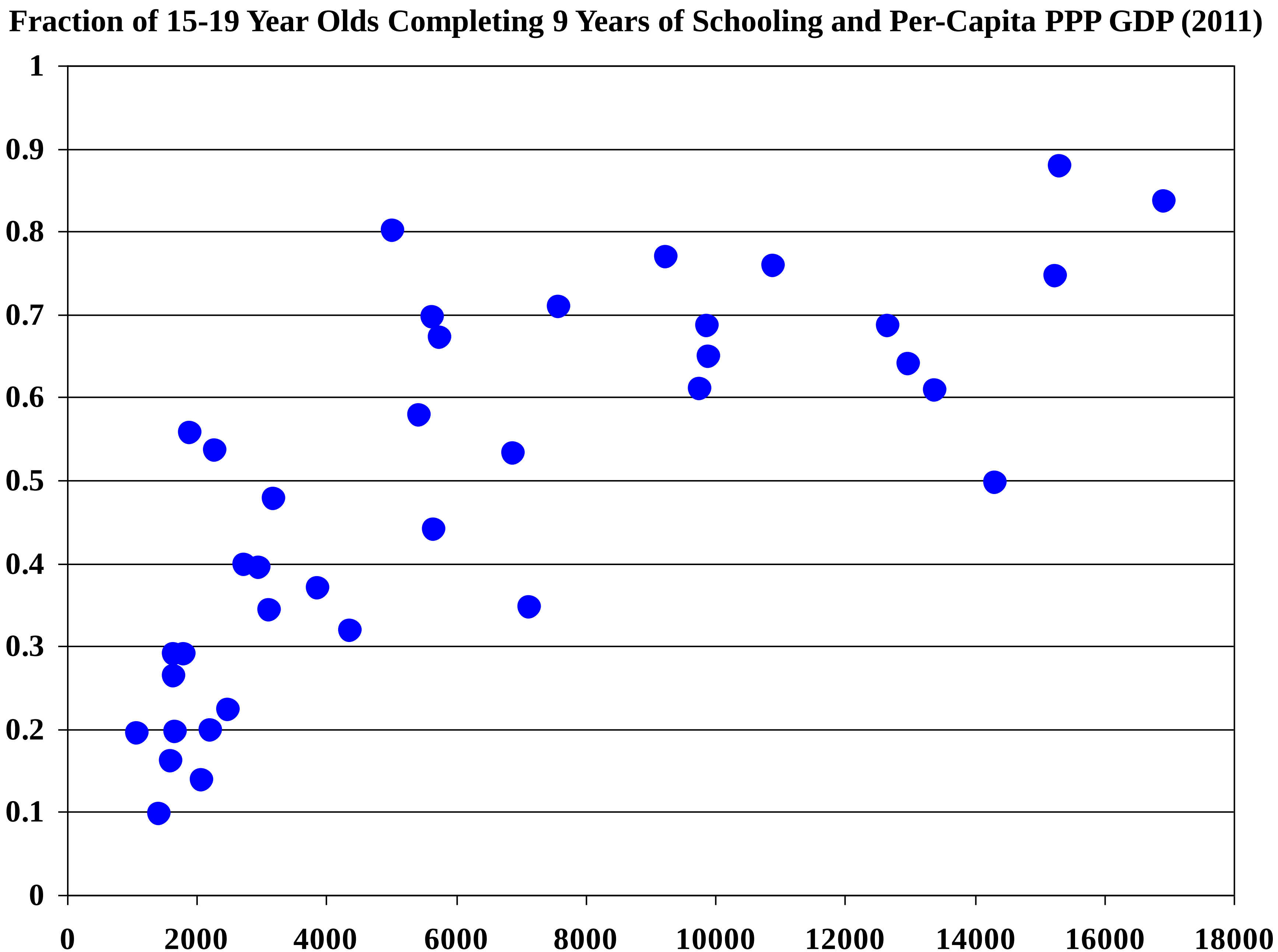
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1
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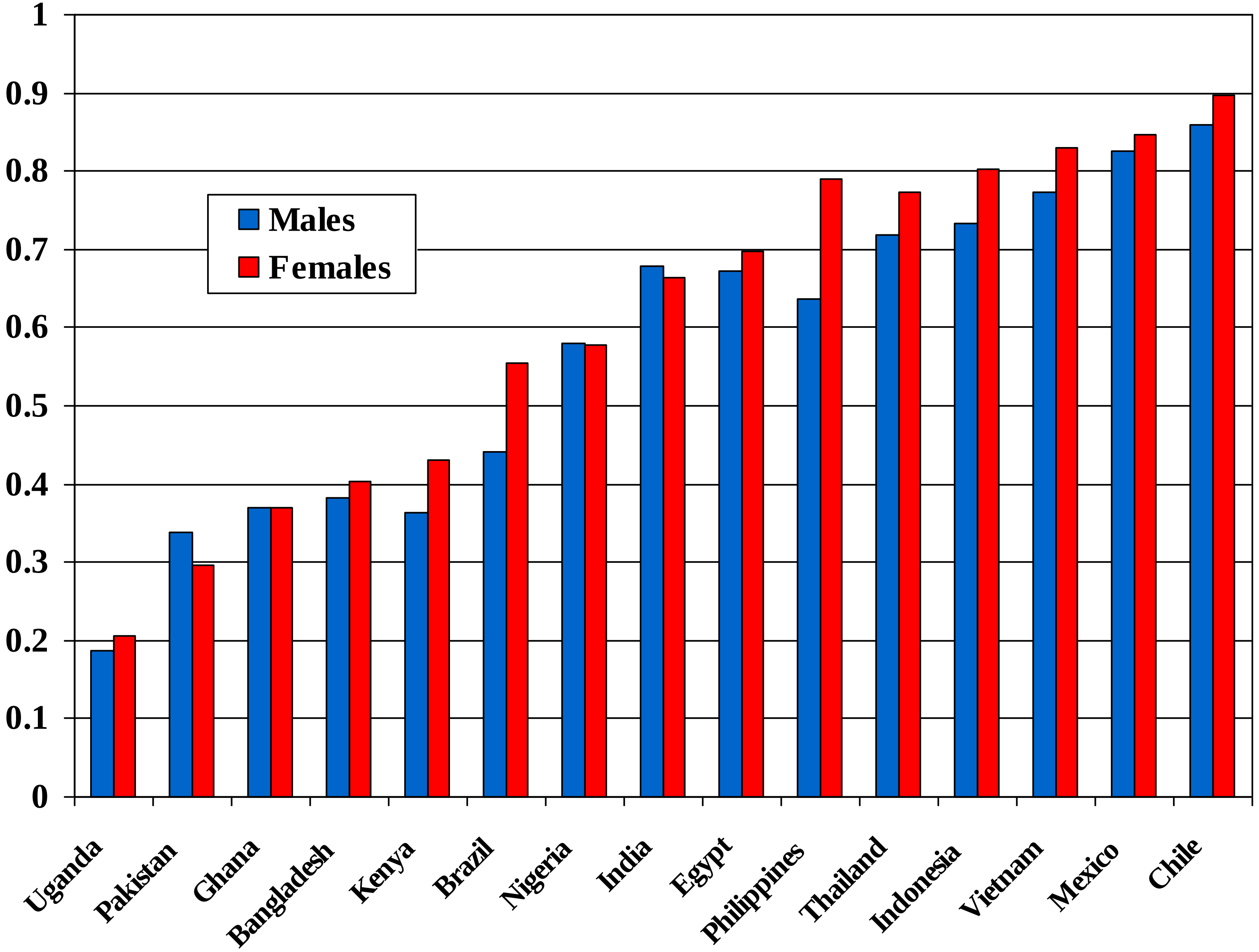
Fraction of 15-19 Year Olds Completing 9 Years of Schooling, by Country and Gender



The productivity of schooling

Is the rate of return to schooling fully informative about the productivity of schooling?

No.

What do we need to know?

How do we measure productivity?

What determines the productivity of schooling?

Start with why schooling can increase economic growth.

What is the role of schooling and health in fostering 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: central point - learning externalities.

        new knowledge embedded in investments in new machines by individual firms spillover

Is there learning from others? Does schooling facilitate learning?

B. Lucas: non-diminishing returns to human capital.

Additions to human capital are greater the higher the level of human capital.

Higher growth from greater productivity of human capital in producing human capital (also individual returns greater the higher the aggregate level of HC).

Presumes human capital is productive in general, not just in producing more human capital.

Is schooling always productive?

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

Note: No direct role for health in steady-state growth models.

Micro Studies of Schooling Returns

Many studies of schooling returns use earnings of salary/wage workers

Two problems:

1. Most workers in low-income countries are not wage workers.

    Rural India, 1999: 45% of primary activities of men aged 25-55 *not* in wage or salary work (61% in 1982)

2. Wages may not reflect productivity: e.g., artificially inflated government salaries:

    Egypt, 1998: government employs 70% of university graduates, 63% of those with intermediate schooling +

    Cote d'Ivoire, 1988: government employs 50% of > prim.

Most popular wage equation:

"Mincer" earnings equation for worker i in country j:

$$logY_{ij} = \alpha_j + \beta_j S_{ij} + \gamma_{j1}\, exp_{ij} + \gamma_{j2}\, exp_{ij}^{\;2}$$

where β_j = "rate of return" to schooling in country j

What determines β_j?

Where does this equation come from?

1. Most popular wage function (Mincer wage function). For country j:

$$W(S_i)_j = W(0)_j e^{\beta(j)S(i)}$$

Based on arbitrage model (Adam Smith) and time-discounting:

A. Define lifetime income y for infinite-lived agent with schooling S_i

$$y(S_i) = \int_S W(S_i)_j e^{-r(j)t} dt$$

where r(j) = discount rate in j

assuming W=0 when schooling is being acquired

B. In equilibrium, lifetime incomes for all persons at any schooling level must be equal (arbitrage assumption):

$$y(S'_i) = y(S_i) \text{ for any S, S', including S=0}$$

therefore $\beta_j = r_j$

What is most important in accounting for differences in the productivity of schooling across countries?

Marginal product of worker of given schooling S in country j:

$$\partial Q_j/\partial L_j = w_j = w(0)_j e^{\beta(j)S}$$

Addition to marginal product from increasing schooling by one unit:

$$\partial^2 Q_j/\partial L_j \partial S = [w(0)_j e^{\beta(j)S}]\beta(j)$$

How much do Rates of Returns to Schooling Vary Across Countries?

Classic source, used in many macro studies:

> Psacharopoulos, G., Patrinos, H. A. "Returns to Investment in Education: A further update" *Education Economics* 12:2 (2004): 111-134.

How much do base wages (W_0) vary across countries?

Appendix B: 52-country sample of Mincer regression coefficients

COUNTRY	EXP	EXP^2	S	YEAR	#OBS	REFERENCE
Argentina	.052	-.00070	.107	1989	2965	P
Australia	.064	-.00090	.064	1982	8227	P
Austria	.039	-.00067	.039	1987	229	P
Bolivia	.046	-.00060	.073	1989	3823	P
Botswana	.070	-.00087	.126	1979	492	P
Brazil	.073	-.00100	.154	1989	69773	P
Britain	.091	-.00150	.097	1972	6873	P
Canada	.025	-.00046	.042	1981	4642	P
Chile	.048	-.00050	.121	1989	26823	P
China	.019	-.00000	.045	1985	145	P
Colombia	.059	-.00060	.145	1989	16272	P
Costa Rica	.042	-.00050	.105	1989	6400	P
Cote d'Ivoire	.053	-.00008	.207	1985	1600	P
Cyprus	.092	-.00140	.098	1984	3178	P
Denmark	.033	-.00057	.047	1990	5289	R&S
Dominican Republic	.055	-.00080	.078	1989	436	P
Ecuador	.054	-.00080	.098	1987	5604	P
El Salvador	.041	-.00050	.096	1990	4094	P
Greece	.039	-.00088	.027	1985	124	P
Guatemala	.044	-.00060	.142	1989	8476	P
Honduras	.058	-.00070	.172	1989	6575	P
Hungary	.034	-.00059	.039	1987	775	P
India	.041	-.00050	.062	1981	507	P
Indonesia	.094	-.00100	.170	1981	1564	P
Ireland	.061	-.00100	.079	1987	531	C&R
Israel	.029	-.00046	.057	1979	1132	P
Italy	.010	-.00027	.028	1987	197	P
Jamaica	.083	-.00110	.280	1989	1172	P
Kenya	.044	-.00200	.085	1980	1600	A&S
South Korea	.082	-.00140	.106	1986	4800	P
Malaysia	.013	-.00004	.094	1979	605	P
Mexico	.084	-.00100	.141	1984	3425	P
Morocco	.068	-.00070	.095	1970	2422	P
Netherlands	.035	-.00049	.066	1983	1888	P
Nicaragua	.050	-.00080	.097	1978	962	P
Pakistan	.106	-.00060	.097	1979	1568	P
Panama	.066	-.00080	.126	1989	5436	P
Paraguay	.058	-.00090	.103	1989	1084	P
Peru	.053	-.00070	.085	1990	1625	P
Philippines	.023	-.00060	.119	1988	4283	P
Poland	.021	-.00036	.024	1986	5040	P
Portugal	.025	-.00040	.094	1985	21823	P
Singapore	.062	-.00100	.113	1974	1247	P
Spain	.049	-.00060	.130	1990	635	AR&S
Sweden	.049	-.00000	.026	1981	2996	A
Switzerland	.056	-.00069	.072	1987	304	P
Tanzania	.041	-.00100	.067	1980	1522	A&S
Thailand	.071	-.00088	.091	1971	3151	C
Uruguay	.051	-.00070	.090	1989	6567	P
USA	.032	-.00048	.093	1989	8118	K&P
Venezuela	.031	-.00030	.084	1989	1340	P
West Germany	.045	-.00077	.077	1988	2496	K&P

Base Wage W_0 and the "Poverty Line"

Worldwide poverty in 2017 (World Bank):

689 million people (9.2%) < \$1.90 per day = \$0.24/hour

1.8 billion people (24.1%) < \$3.20 per day = \$0.40/hour

3.3 billion people (43.6%) < \$5.50 per day = \$0.69/hour

US (prop.) minimum wage = \$120 per day = \$15.00/hour

Alternative skill price approach:

Wage of worker i in country j =

$$W_{ij} = \omega_j X_{ij}$$

where ω_j = skill price in country j

X_{ij} = number of skill units possessed by i in j

Role of schooling is to produce skill

This is one skill-type formulation

Might be different skill types, with prices for each

Estimation of skill prices from micro data on wages "around the world":

Assume the number of skill units of a worker is a function of schooling, other human capital variables and an unobservable skill endowment; for example:

(8) $$x_{ij} = \mu_{ij}\exp(\beta_j S_{ij} + \mathbf{I_{ijk}}\gamma_k),$$

where S_{ij} = schooling, β_j = country-specific schooling "return",
μ_{ij} = skill endowment

$\mathbf{I_{ijk}}$ = vector of other human capital variables for worker i in country j

$\boldsymbol{\gamma_k}$ = a vector of coefficients

Then the log of worker i's wage in country j, from (1), is

(9) $$Ln(W_{ij}) = Ln\omega_j + \beta_j S_{ij} + \mathbf{I_{ijk}}\boldsymbol{\gamma_k} + Ln\mu_{ij}.$$

The intercepts in (9), which are allowed to differ across countries, provide the log of the skill price for each country represented in the data.

Data for Estimating World Skill Prices

What are the <u>micro</u> data that can be used to estimate wages, by schooling, for countries of the world?

Requires <u>comparable</u> information on the earnings of workers of the same skill across all countries of the world to assess migration and wage-determination models

There are three sources:

A. The New Immigrant Survey Pilot (1996)

B. Occupational Wages Around the World (2000)

C. The New Immigrant Survey (2003)

Estimation strategy for identifying skill prices and their effects on migration

1. Estimate wage equation (9) for all workers in the NIS-P or NIS, based on earnings in last job before coming to the United States - home country wages.

Allow β to vary across countries:

a. Non-parametrically: individual dummy interactions

$\beta_j = \Sigma\delta_j S_{ij}$, where the δ_j are country dummy variables

b. As a function of measures of quality Q_j of schooling: (Mincer test)

$\beta_j = f(Q_j$ for primary, secondary and tertiary schools)

Measures: teacher-pupil ratios for primary and secondary schools (Barro-Lee)

World ranking of universities - any ranked, mean rank (top 200): *Times Higher Education*

Table 4
FE-Country Log Wage Regression Coefficients:
Log Hourly Wage at the Last Job Before Coming to the United States (Mincer Test)

Sample	All Immigrants		College Grad	No College
Origin-country variable	(1)	(2)	(3)	(4)
Years of schooling completed	.0968 (12.04)	.0882 (7.79)	.0250 (0.22)	.0533 (0.98)
Years of schooling*any ranked universities in country	--	.149 (2.19)	.448 (1.97)	.0396 (0.27)
Years of schooling*mean rank of universities in country	--	-.00127 (1.98)	-.00428 (2.20)	-.00026 (0.19)
Age at last job	.123 (7.10	.125 (7.21)	.0717 (2.71)	.0459 (1.84)
Age at last job squared	-.00142 (7.00)	-.00144 (7.08)	-.0010 (3.06)	-.00065 (2.27)
R^2	.222	.223	.224	.244
Number of workers	3,364	3,364	1,605	1,739
Number of sending countries	131	131	116	114

Estimates of Skill Prices Using the NIS

1. Skill prices or $W(0)_j$ differ significantly across countries

2. Rejection of Mincer-Smith equilibrium:

A. Quality matters (not spurious)   B. Non-proportional wage differences

Figure displays the estimated (PPP-adjusted) skill prices for 19 Asian countries, based on the NIS-P and OWW data sources (correlation = .66)

See differences in skill prices are enormous, however estimated:

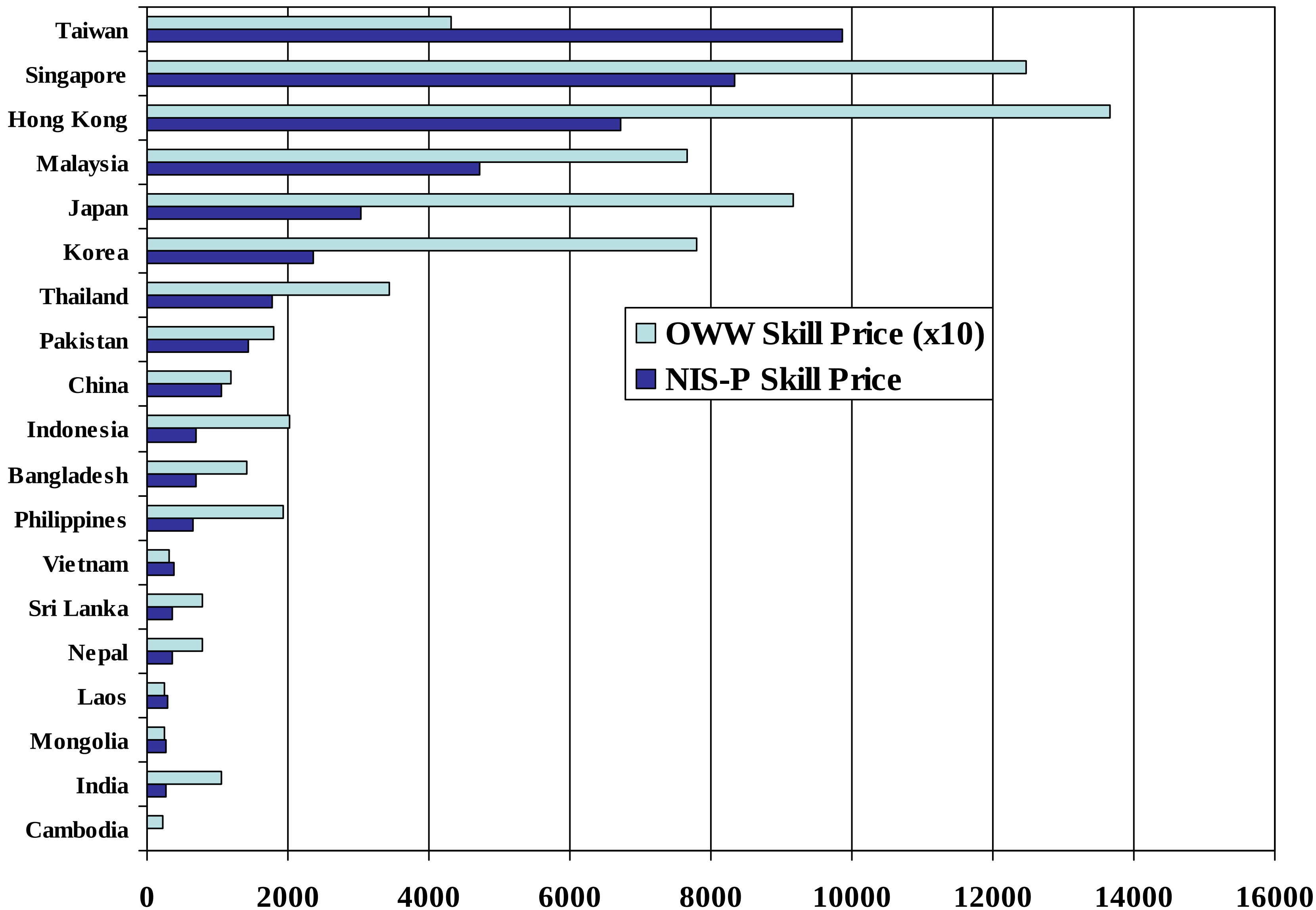
Skill price in S. Korea is 3.5 to 5.5 times that in Bangladesh

How do skill prices relate to earnings by educational level across countries?

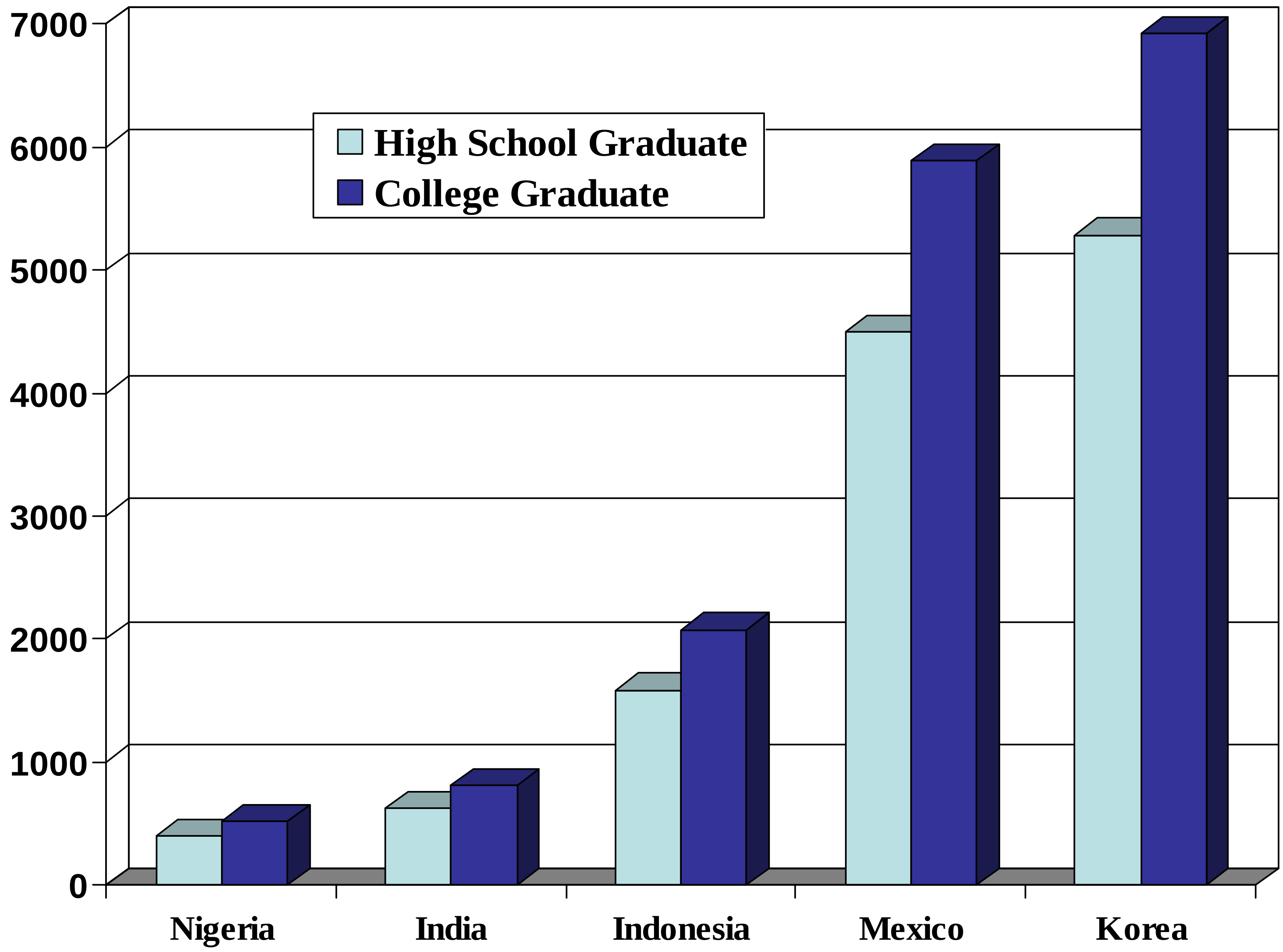
Compute for selected countries earnings for high-school and college graduates using skill price estimates

Assume rate of return to schooling is .07 (β) for all countries.

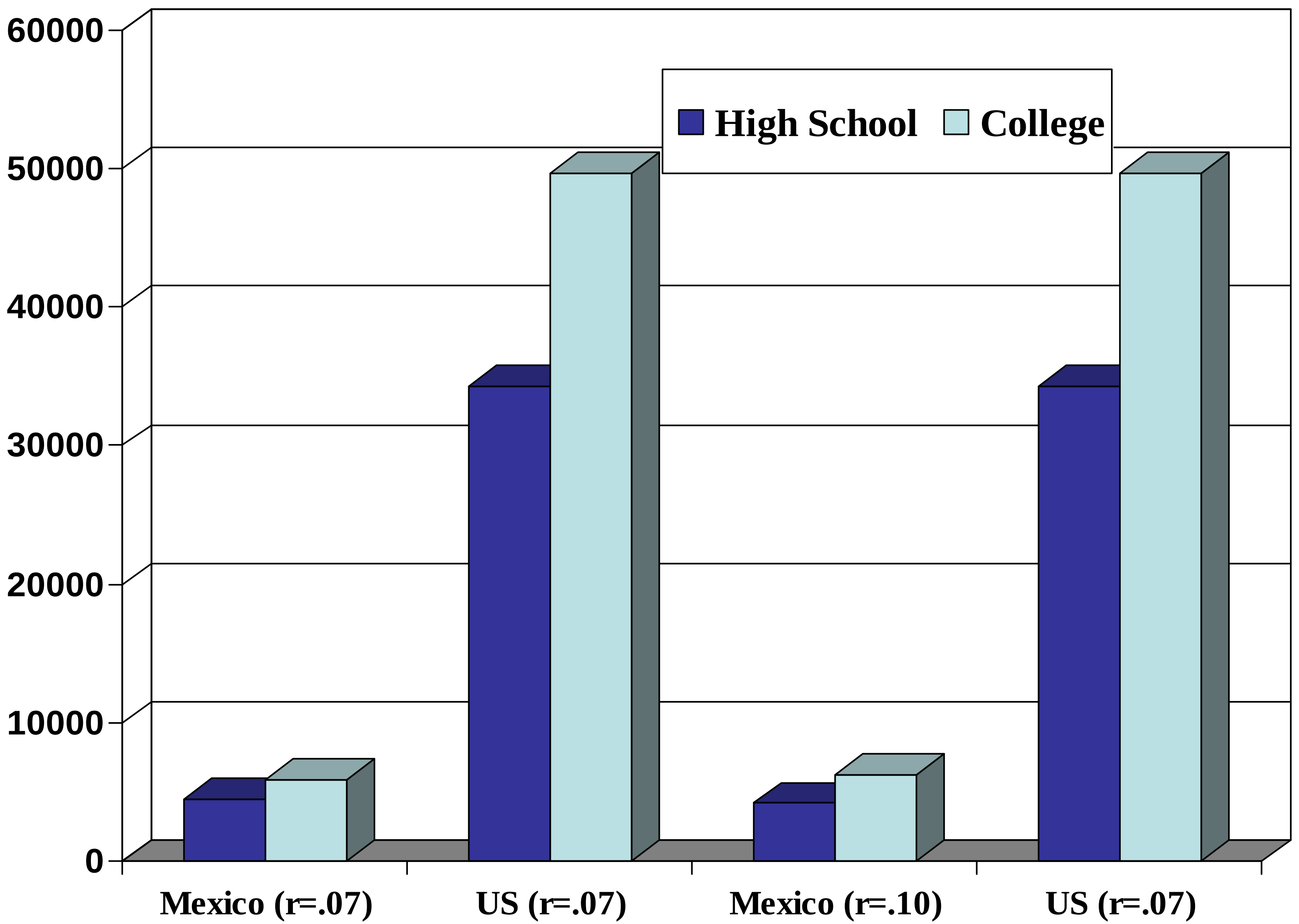
Estimated PPP $ (1995) Skill Prices for 19 Asian Countries, by NIS-P and OWW Sources



Estimated (Purchasing-Power Adjusted 1996) Earnings of High School and College Graduates, Across Selected Countries Around the World (r=.07)



PPP-Adjusted 1996 Estimated Annual Earnings in Mexico and the United States, By Schooling Level and Schooling Return



What Determines the Productivity of Schooling?

Seen the enormous variation in the increased productivity from increasing schooling.

Based on wages, but can we measure productivity directly?

Focus on the agricultural sector.

> Measurement of output, technology transparent relative to other occupations/industries.
>
> Data are richer - on inputs, characteristics of workers.
>
> The main occupation of workers in mow-income countries (42% in India, 30% in China, 61% in Kenya).

Does More Schooling Raise Farm Productivity?

Assume we can estimate the production function:

$$Q = \theta(S)\mathrm{F}(L, V, A),$$

where S = schooling, V=variable inputs, A=land owned.
$\theta(S)$ = TotalFactorProductivity

Is the appropriate test estimating - $\theta(S)'$?

What question does the estimate answer?

How total output varies by schooling *holding constant all inputs*.

Simplified profit (value-added) function - one variable (V) input:

$$\text{Max } \pi = p\theta \mathrm{F}(V, A) - \mathrm{p_v} V$$

$$\text{FONC: } d\pi/dV = (\mathrm{p}\theta \mathrm{F_v} - \mathrm{p_v}) = 0$$

Suppose S contributes to better choices:

The full marginal contribution of schooling =

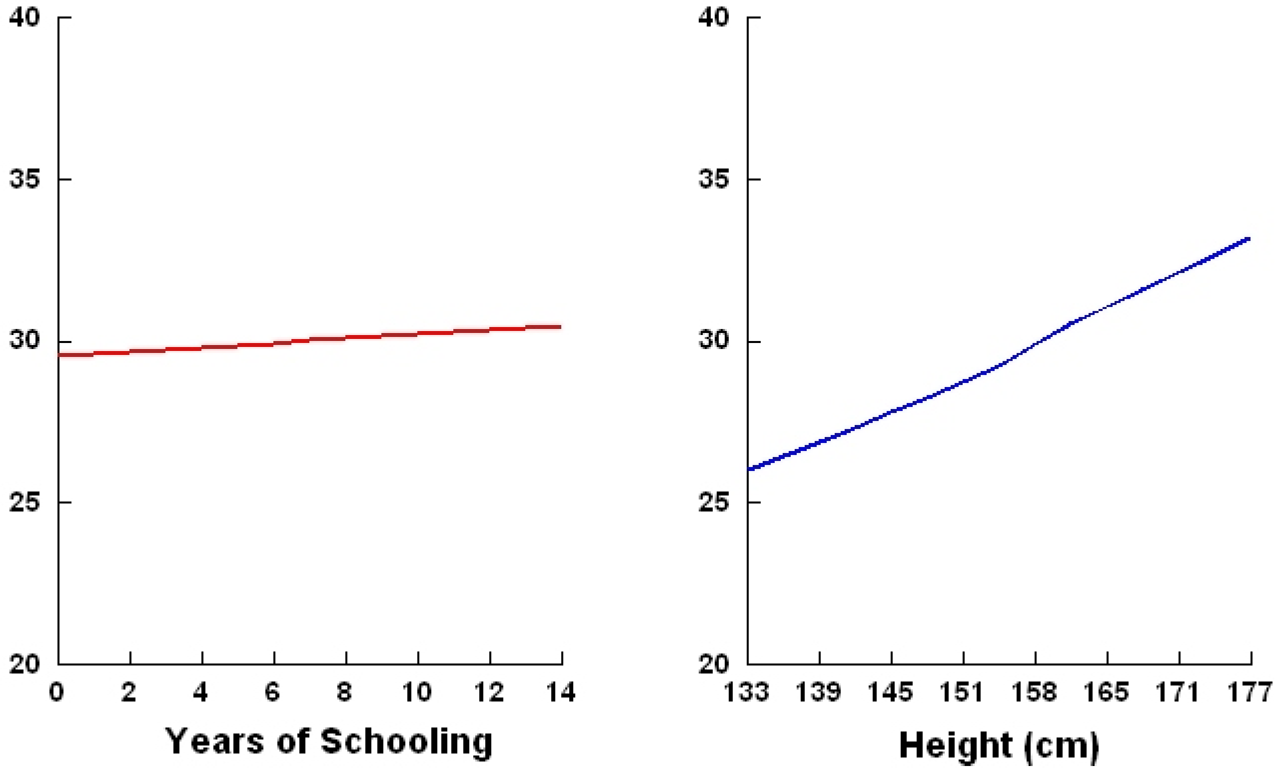
$$d\pi/d\mathrm{S} = (\mathrm{p}\theta \mathrm{F_v} - \mathrm{p_v}) dV/dS + \mathrm{p}\theta(S)'\mathrm{F} > 0$$

The first term is the “allocative” effect of schooling

Thus, we obtain the total contribution of schooling from estimating the *profit function* $\pi = \pi(\mathrm{S, A, p_v})$ to get the expression above.

Under what circumstances is the allocative effect going to be most important?

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



Schooling, Technology Information and Use-Efficiency:

Contraceptive "Revolution"

Rosenzweig and T. Paul Schultz, "Schooling, Information and Nonmarket Productivity: Contraceptive Use and Its Effectiveness," *International Economic Review* 30, No. 2 (May, 1989): 457-477.

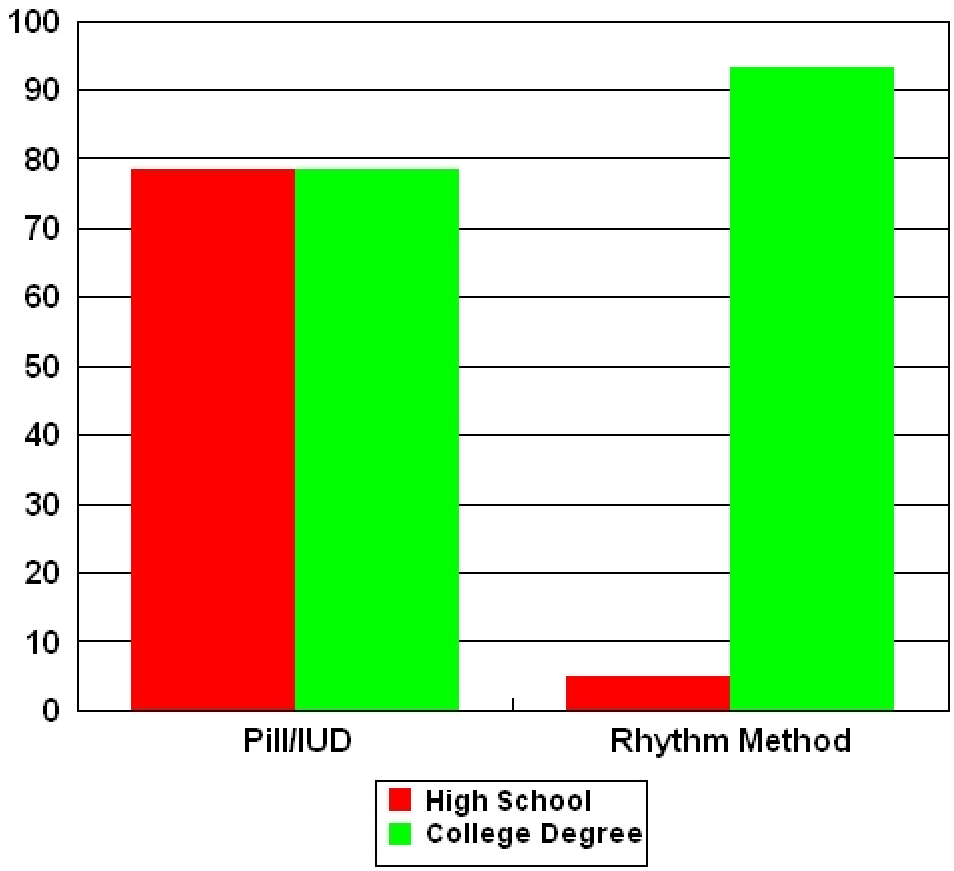
National Fertility Survey, 1965

5615 completed interviews: currently married women aged <55

88% response rate ("US gold standard" = 70%)

National Fertility Surveys, 1970 and 1975 similar

Contraceptive Use-Efficiency Among U.S. Women by Contraceptive Method and Schooling



Schooling and the Indian “Green Revolution”

Two questions:

1. Did the flow of challenging new technologies increase the return to schooling?

    a. Which level of schooling?

    b. For whom?

2. Did investment in schooling respond to the change in the return to schooling?

    a. By whom?

    b. Did school availability play a role?

Features of the "Revolution"

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

    Followed by substantial public investment in local crop improvements, subsidies of fertilizer, credit in "winning" areas.

2. 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.

3. HYV seeds more sensitive to water (rainfall), fertilizer (soil) than traditional seed varieties.

    HYV seeds only suitable to particular regions.

Thus there is variation in growth potential across areas of India due to soil and weather that differentially affect the returns to learning skills.

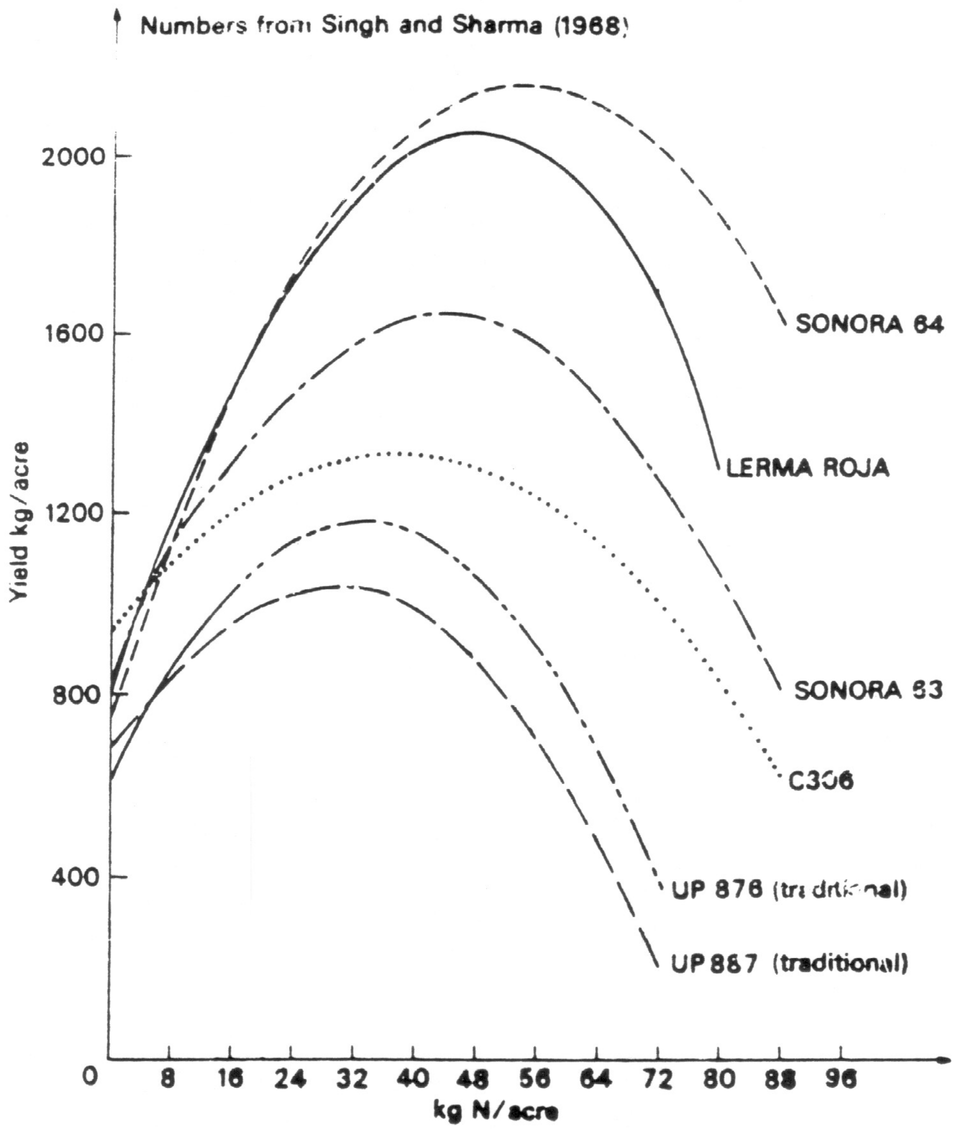


Fig. 7.1

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.

ARIS-REDS Panel Data

Began in 1968 with three-year panel of 4,118 rural households in 250 villages.

Representative sample (with weights) of entire rural population of India.

A. 1968-71 panel of 4,118 households

B. Second round of panel in 1982.

C. Third round in 1999.

D. Fourth round in 2006-2008.

NCAER ARIS-REDS Sample Villages

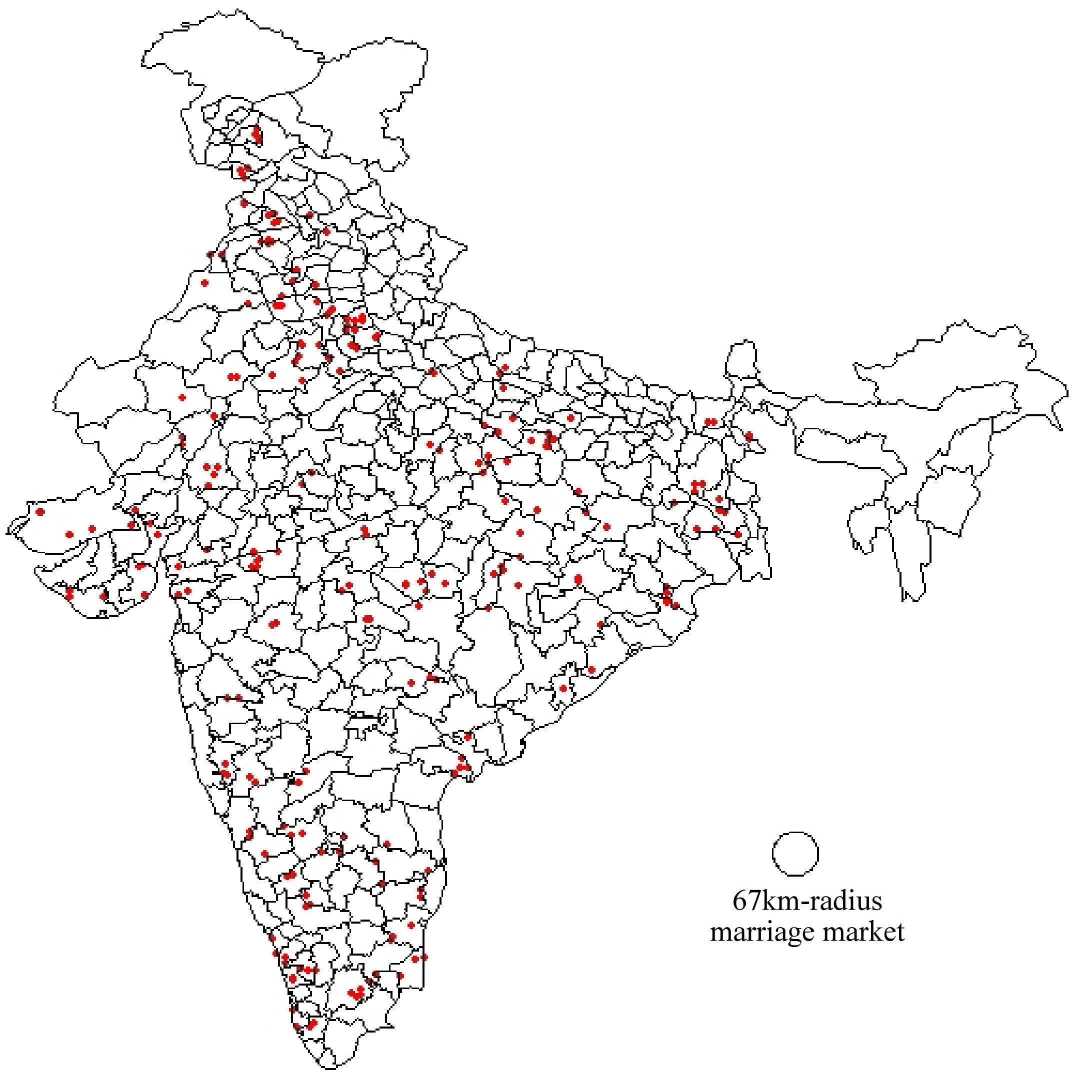


Table 1
Determinants of HYV Adoption by 1971:
Farm Households in HYV-Using Districts

Variable	Means (S.D.)	Probability Ever Adopted (Probit)
Household Schooling:		
Primary Highest	.493	.524
	(.500)	(8.55)
Secondary Highest	.213	.140
	(.410)	(1.89)
Household Owned land (acres)	10.5	.0159
	(12.5)	(6.40)
Village Agricultural Extension	.560	.162
	(.496)	(3.04)
Village Primary Highest	.955	.012
	(.207)	(0.09)
IADP	.222	.340
	(.416)	(5.29)
Constant	--	-.726
		(5.57)
N	2532	2532

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

Table 3
Estimates of HYV Use on Farm Profits , by Farmer Schooling Level
1969-71

Variable\Est. meth.	FE-IV[a]	FE-IV[a]
HYV acreage	722	-10100
	(0.65)[c]	(3.53)
HYV×schooling	--	7650
		(3.07)
HYV×proportion land irrigated	--	6130
		(2.54)
Farm equipment	4.21	2.37
	(2.51)	(1.16)
Irrigation assets	.768	.273
	(1.73)	(0.54)
Other farming assets	5.40	8.21
	(2.69)	(3.30)
Adverse weather in village	-369	-477
	(3.39)	(3.61)
N	1517	1517

[a]Farmers in areas with some HYV use (74 districts) that cultivate in crop years 1970 and 71. All variables except weather are instrumented.
[c]Absolute values of asymptotic t-ratios in parentheses.

Microeconometric evidence on learning and schooling

Challenge: master how to use a new technology (Foster and Rosenzweig, 1986)

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

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

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

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

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)

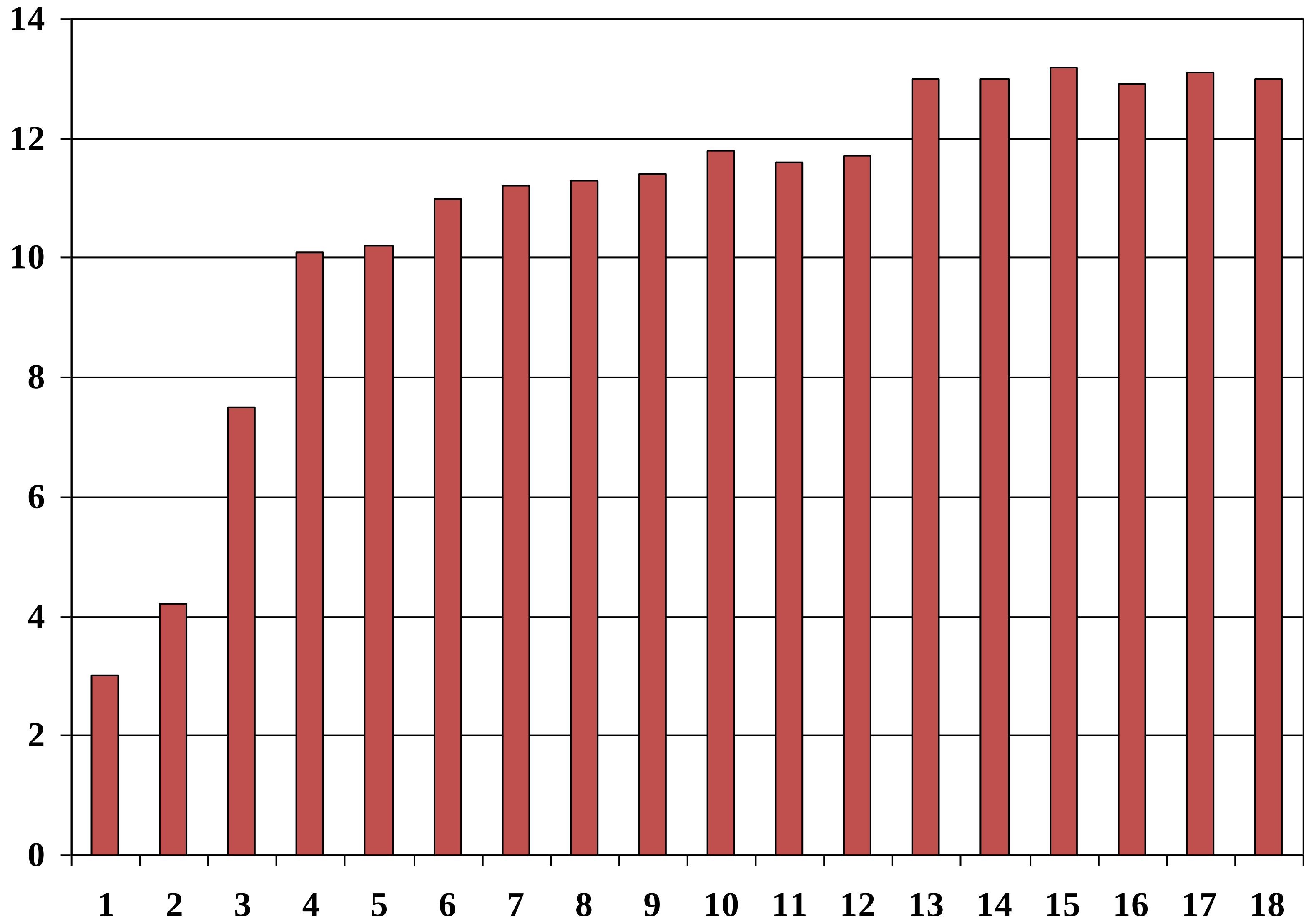
If ρ_0' small and $\rho_l'>0$, then the effect of experience on profits is greater for the more schooled - profit trajectory steeper (faster learning)

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)



2. But, the estimation of the conditional profit function may underestimate total contribution

A method for estimating the total contribution of schooling to profitability under technological change is to estimate the unconditional or meta-profit function Π^m:

(3) $$\pi_t = \Pi^m(S_t, \mathbf{A}_t, w_t, p_t, \theta_t, \mu, \epsilon_t) = \max_{H_t} \Pi^h(H_t, S_t, \mathbf{A}_t, w_t, p_t, \theta_t, \mu, \epsilon_t).$$

1. The total effect of schooling on profits is $\partial\Pi_t^m/\partial S_t$ - the effects of schooling on both the profitability of HYVs and the level of adoption of HYVs.

2. Identifies the effects of technology on the returns to schooling, $\partial\Pi^2{}_t{}^m/\partial S_t\partial\theta_t$.

But, how do you estimate the level of technology θ_t?

Exploit characteristics of green revolution:

1. Area-specific variation in productivity growth after the green revolution:

After the onset of technological change, technology grows in each district at different rates, depending on the area-specific endowments.

2. No area-specific variation in technology before the green revolution

Approximation to the profit function:

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

(4) $$\pi_{ij0}(\ ) = \Sigma\beta_k A_{kij0} + \beta_s S_{ij0} + \beta_L w_{j0} + \beta_F p_{j0} + \mu_{ij} + \beta_\epsilon \epsilon_{ij0},$$

where

$\mathbf{A}$ = vector of farm assets, $\beta_L = -\partial\Pi_t^m/\partial w_t$ = labor demand (duality!)

2. After the green revolution begins the structure of the profit function changes and becomes differentiated across areas: the meta-profit function (5) for district j at time t becomes:

(5) $$\pi_{ijt}(\ ) = \theta_{jt} + \Sigma(\beta_k + \alpha_k\theta_{kjjt})A_{kijt} + (\beta_s + \alpha_s\theta_{jt})S_{ijt} + (\beta_L + \alpha_L\theta_{jt})w_{jt} + (\beta_F + \alpha_F\theta_{jt})p_{jt} + \mu_{ij} + (\beta_\epsilon + \alpha_\epsilon\theta_{jt})\epsilon_{ijt},$$

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 θ_{jt}

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

Problem: variation across areas in profits and schooling could be due to other factors

- fixed attributes of the soil, weather that have independent effects on profits

Solution: look at changes in profits for the same farmer:

Subtracting (4) from (5) yields:

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

where $\Delta\pi_{ijt} = \pi_{ijt} - \pi_{ij0}$, $\tau_{jt} = \Delta\theta_{jt}$ = area-specific technological change

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

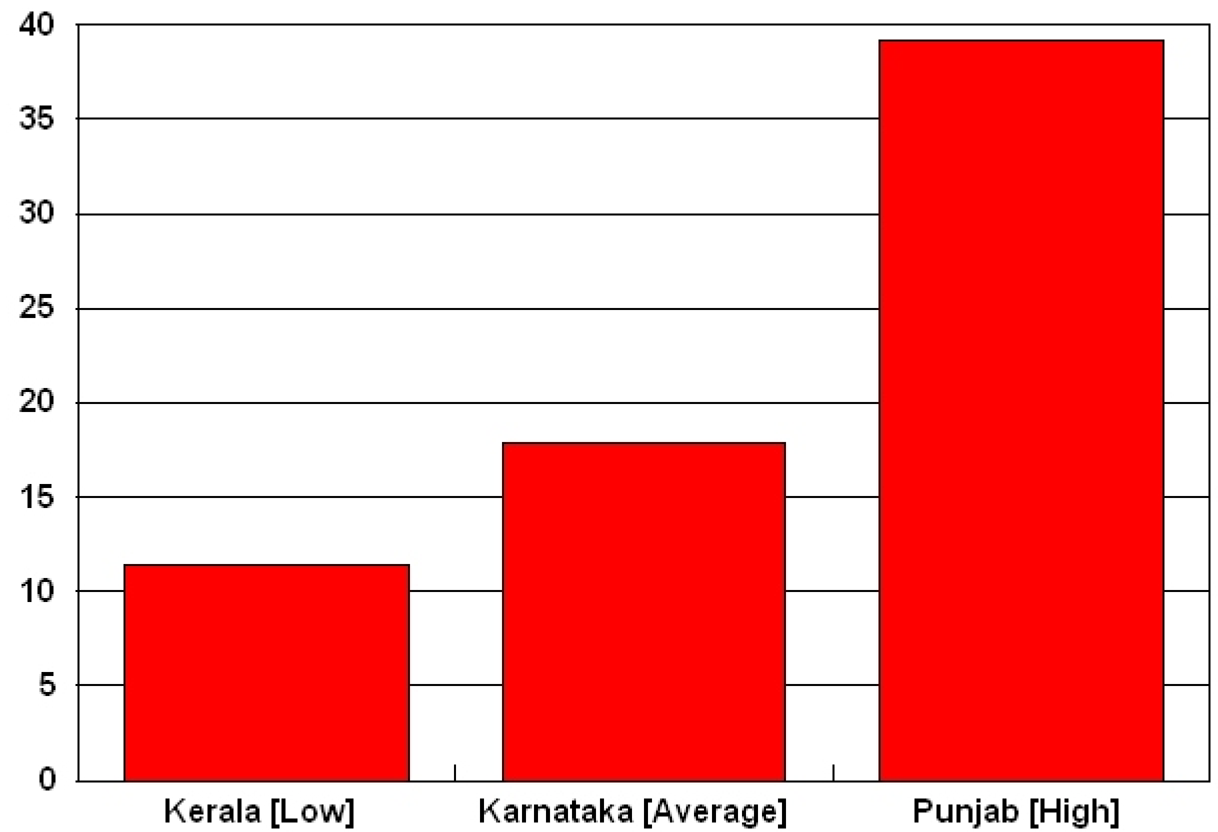
3. The area-specific τ_{jt}: i.e., where technological change was more and less rapid.

(identification from assumptions: θ_{jt} varies across areas, *effect* of θ_{jt} only differs by input or asset)

Table 4
Non-Linear FE-IV Estimates: Conditional Profit Function
with District-Specific Growth Intercepts, 1971 - 1982

Variable	Coefficient	NL-FE-IV
Primary schooling:	β	368
		(2.35)[b]
	α	.556
		(2.55)
Irrigation Assets	β	.139
		(4.20)
	α	.000133
		(3.11)
Irrigated area (acres):	β	169
		(9.06)
	α	-.102
		(2.62)
Unirrigated area (acres):	β	67.3
		(5.80)
	α	-.180
		(3.16)
Value of farm machinery:	β	.101
		(3.16)
	α	-.0000525
		(1.63)
Value of animal stock:	β	.434
		(6.59)
	α	-.000164
		(3.59)
Male wage rate, Rs. per day:	β	33.97
		(0.37)
	α	-.116
		(6.34)
N		1788

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



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.

Munshi (2004)

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

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 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

Does schooling investment responds to changes in returns?

1. Indian Green revolution: in areas with higher productivity growth due to new HYV seeds, do we see increased school enrollments (Foster and Rosenzweig, 1995)?

   Response by cultivator households. landless?

2. Indian reforms opening up the economy

   In Mumbai increase in earnings returns to knowing English in post-reform years.

   Dramatic rise in enrollments in expensive, English-medium schools, across all caste, income groups, especially low-caste women (Munshi and Rosenzweig, 2006).

Green Revolution and the Change in School Enrollments

The estimate of the τ_{jt} are the residuals from predicting profit change over time, net of the changes in:

assets, prices, weather and the returns to assets.

Thus, the τ_{jt} also contain measurement error; if used as a regressor, would lead to bias (to zero).

Instead use τ_{jt} as an instrument to predict yields and yield growth (changes in τ_{jt} between the period 1968-71 and 1971-82).

Did the growth in yields affect changes in school enrollments?

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

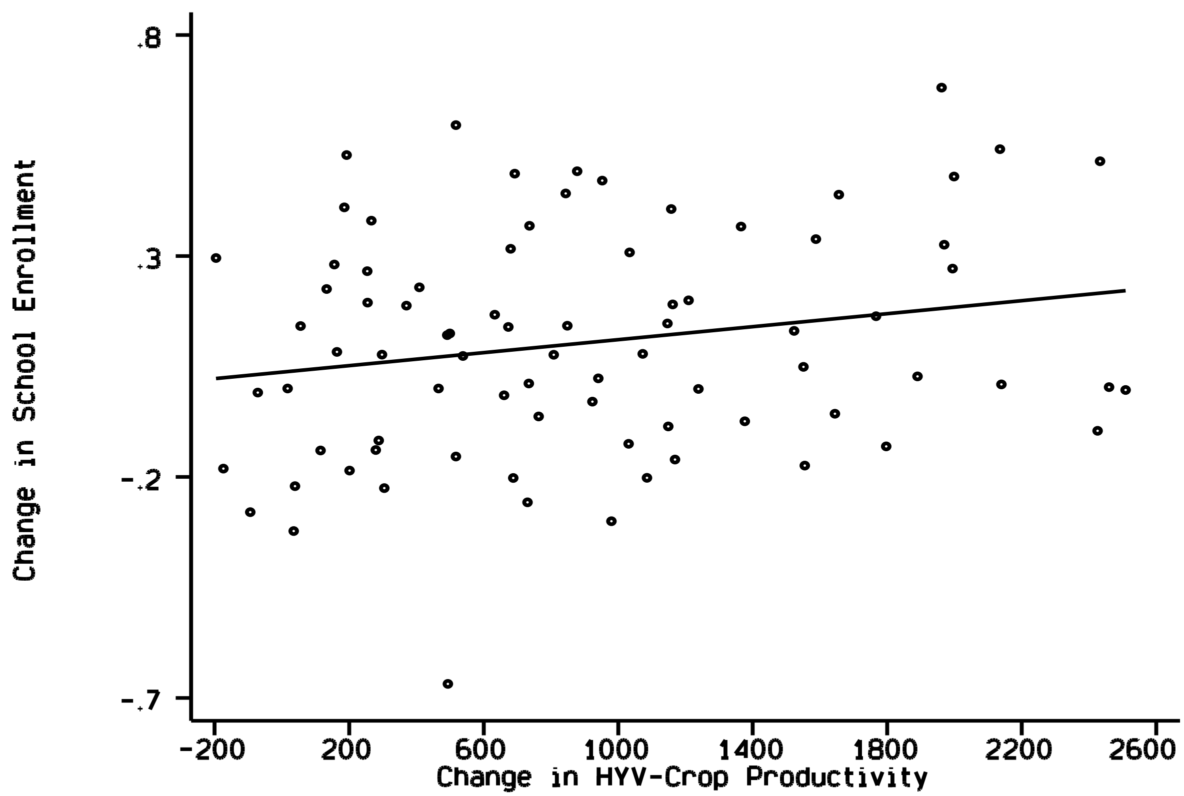


Table 5
Agricultural Productivity Growth and School Enrollment Rates:
Children Aged 5-14[a]

	Sample Means (S.D)		IV-Fixed Effects Coeffs.	
Variable	1971 Level	71-82 Change	(1)	(2)
Yield (Rs.) per hectare ($x10^3$)	3.090 (.918)	.927 (.671)	.158 (4.28)[b]	.141 (3.49)
Yield growth ($x10^3$)	.394 (.451)	-.0491 (.568)	.225 (1.97)	.348 (2.61)
Yield growth x nonfarm household ($x10^3$)	--	--	--	-.704 (2.26)
Yield level x nonfarm household ($x10^3$)	--	--	--	.0434 (0.85)
School built in village	.944 (.231)	.085 (.280)	.572 (2.89)	.622 (2.92)
Male wage rate (Rs. per day)	2.58 (1.13)	.452 (1.16)	-.102 (3.02)	-.105 (2.96)
Wealth ($x10^6$)	.013771 (.02310)	.001454 (.00224)	1.51 (1.32)	1.34 (1.12)

[a]Sample size=847 households. Data sources: ARIS, REDS, Vanneman and Barnes.
[b]Absolute values of asymptotic Huber t-ratios in parentheses. All variables are instrumented.

Table 2
ICRISAT VLS 2009-2014: Estimates of the Effect of Schooling on Real Agricultural Output and Profits and Own Hourly Wages Among Men with the Maximum Schooling Level in Farm Households

Dependent variable	Log Real Output per Acre		Real Profits per Acre		In Wage Market	Log Real Hourly Wage	
Estimation method	OLS		OLS		ML Probit	OLS	ML Selection
Primary	0.100 (0.066)	0.067 (0.065)	383 (345)	312 (327)	-0.518 (0.110)	-0.0248 (0.0229)	-0.0369 (0.0267)
Secondary	0.371 (0.060)	0.352 (0.057)	844 (323)	778 (323)	-1.29 (0.120)	-0.00569 (0.0251)	-0.0386 (0.0387)
Age	-0.017 (0.011)	-0.014 (0.011)	27.8 (76.5)	42.7 (78.1)	0.0959 (0.0147)	0.0074 (0.0044)	0.0099 (0.0044)
Age squared	0.00015 (0.0001)	0.00013 (0.00010)	-0.38 (0.752)	-0.505 (0.770)	-0.00120 (0.00018)	-0.000098 (0.000050)	-0.00013 (0.000052)
Total land owned	-0.0384 (0.008)	-0.038 (0.0074)	-31.8 (34.7)	-31.9 (34.8)	-0.128 (0.0263)	-	-
Share irrigated land	0.394 (0.101)	0.353 (0.097)	2861 (882)	2905 (910)	-0.233 (0.113)	-	-
Mills-ratio	-	-	-	-	-	-	0.0372 (0.0386)
Land quality variables	N	Y	N	Y	Y	Y	Y
FE village-year	Y	Y	Y	Y	Y	Y	Y
Selection correction	-	-	-	-	-	N	Y
N	2989	2989	2989	2989	4143	989	4143

Standard errors clustered at the household level. Land quality variables include10 soil types, six levels of soil depth and average distance of the plots from the farm household.

Globalization of the Bombay Economy and Schooling Choice

For more than 100 years, Bombay was an industrial city, blue-collar jobs dominated by (lower) sub-caste networks providing job referrals.

Transformation starting in mid-1980's, accelerating in 1990's to prominence of trade, corporate, and financial sectors.

One important consequence of openness: English is principal medium of exchange in globalized world today; English skill valuable in the new economy.

Key schooling choice in Bombay: whether to take instruction in English (private school) or local language (free public school) (Marathi language).

Consequences of choice if choose English medium schooling:

1. Fluency in English and thus potential employability in sectors where English is useful.

2. Ability to continue education in tertiary schools, in which the instruction medium is English.

What happened to the returns to English between the 1980's and 1990's?

Based on retrospective earnings histories: small rise in returns to years of schooling but *large rise in returns to English.*

Did this change the relative enrollments in English-medium schools? By whom?

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

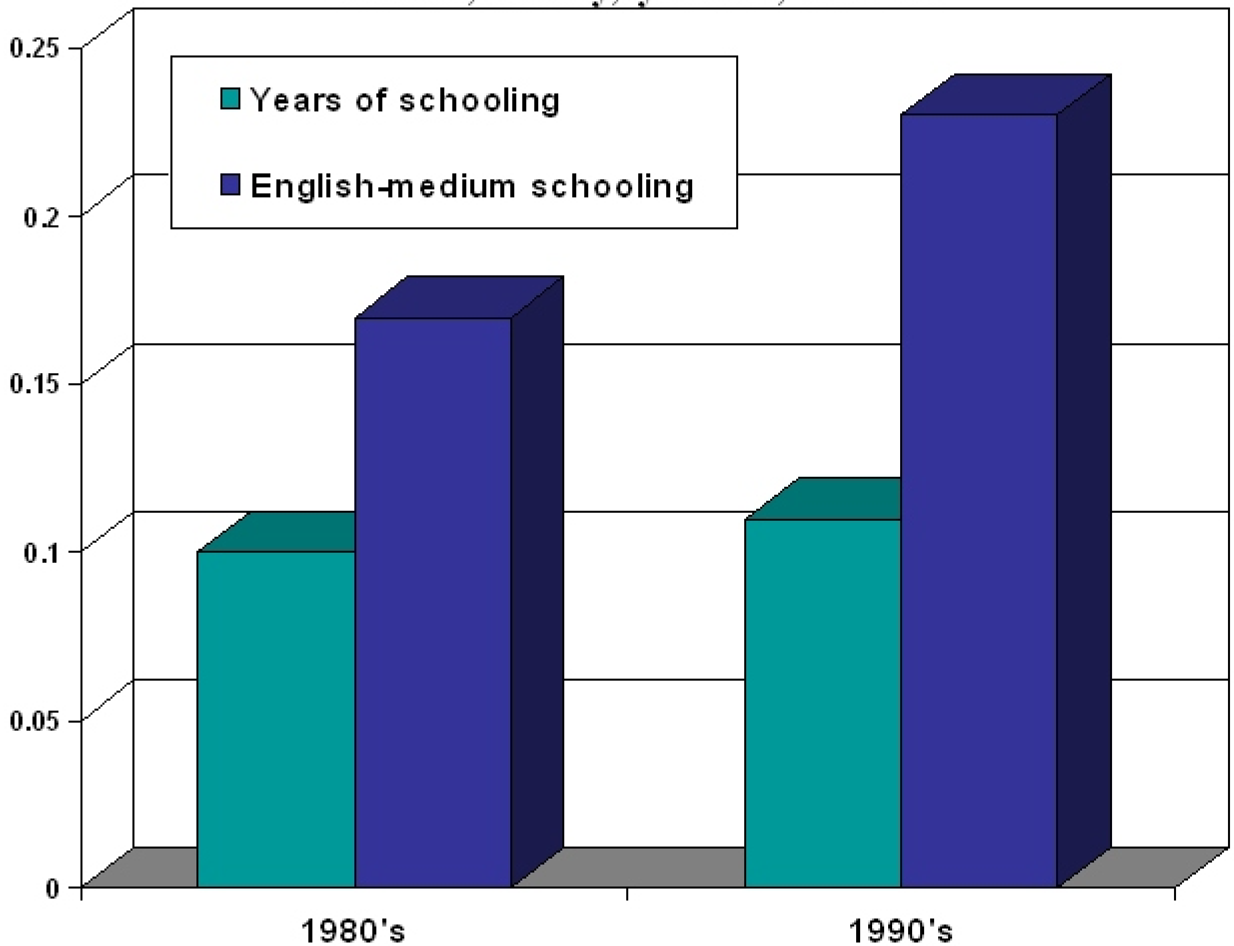
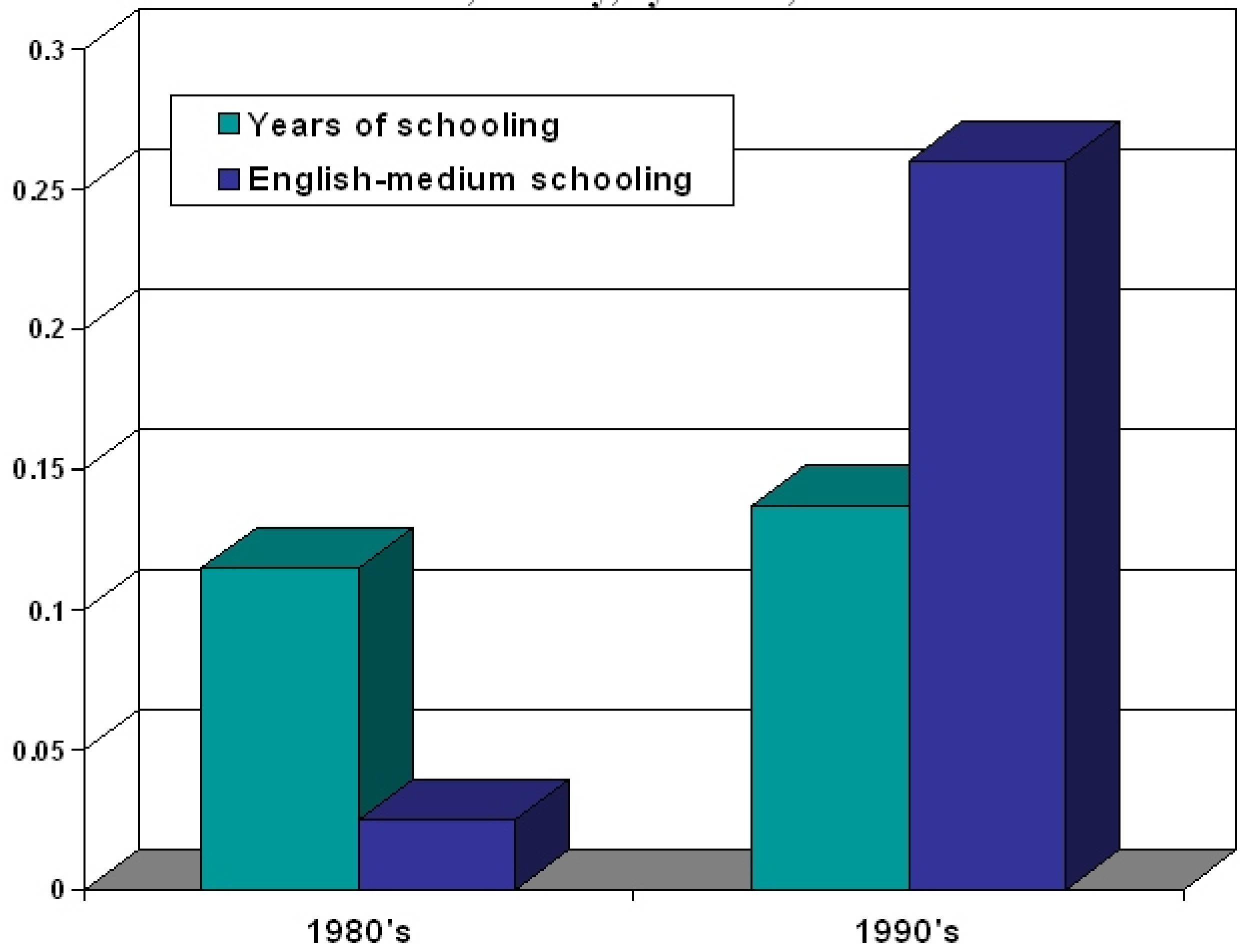


Figure 8: Rates of Return to English-medium Schooling and Years of Schooling for Women in Dadar, Bombay, by Decade, 1980-2000



Pre-reform composition of schools by caste very different:

Rate of English-medium schooling among the upper-caste (wealthy) in 2000 is 15X higher than in the lower castes.

True for both girls and boys.

Did the composition by caste (lower and upper) change in the English medium schools? Convergence?

Barriers to lower caste enrollment:

A. Lower income, credit constraints: cannot afford to switch.

B. Parents of lower-caste students themselves less likely to know English - cannot help with homework if in English.

If these barriers are unimportant:

Change in returns to knowing English should increase the returns to attending an English-medium school and thus:

A. Shift enrollments to English medium schools.

B. Result in a convergence by caste group in the composition of English-medium school students.

Do we see both the shift and convergence after the reforms?

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

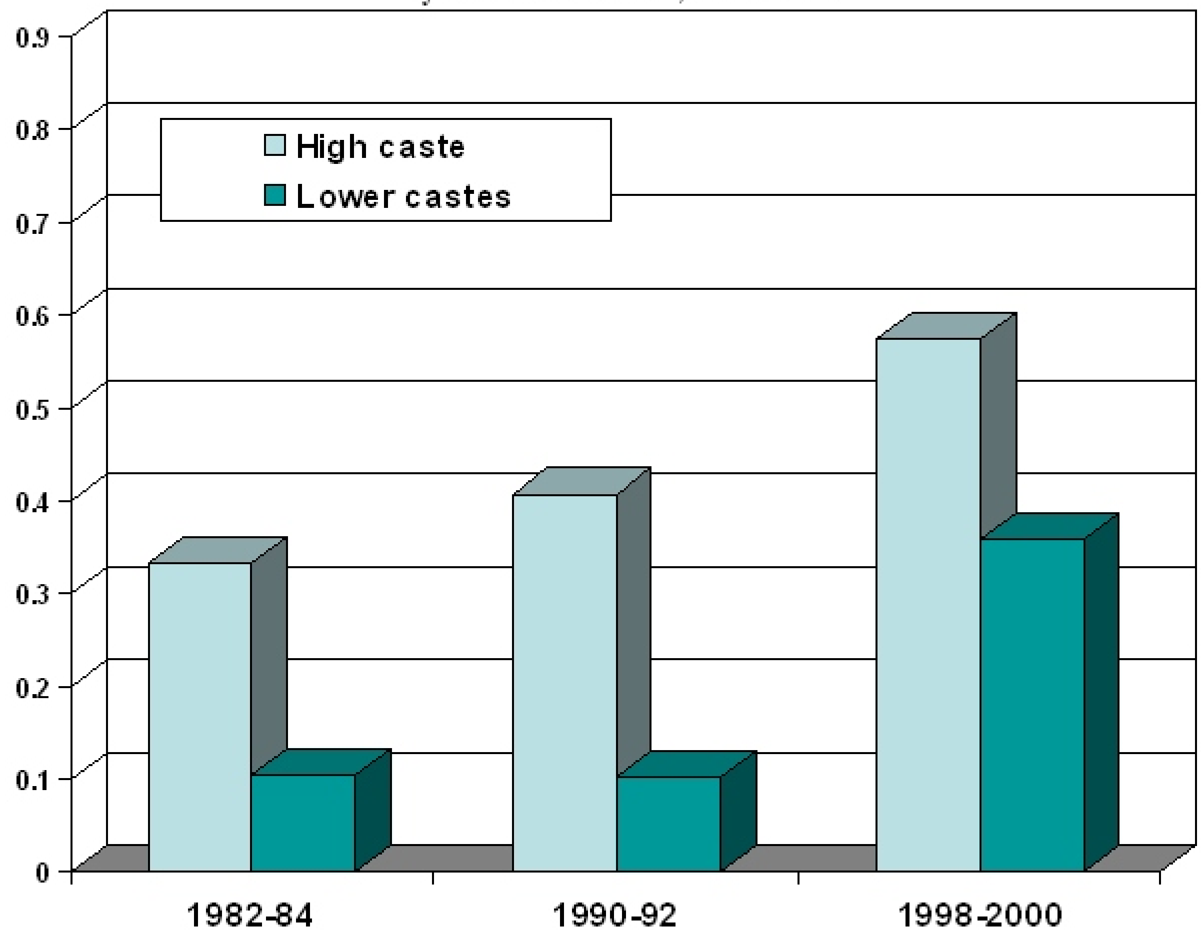
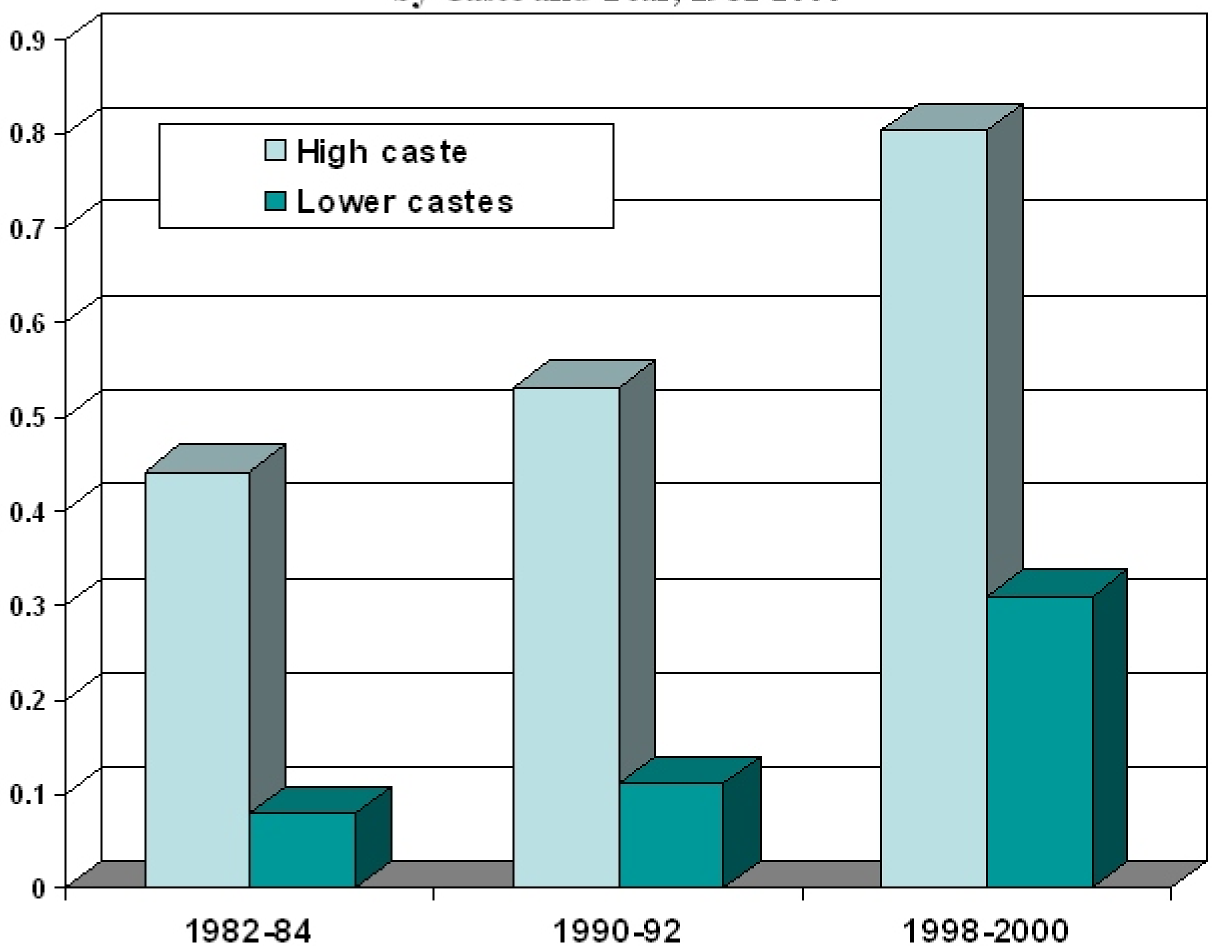


Figure 10: Fraction of Male Students Enrolling in English-medium Schools in Dadar, Bombay, by Caste and Year, 1982-2000



Specific Research Questions:

1. Why are enrollment rates in English-medium schools rising?

   A. Increase in demand for English?

   B. Increase in demand for better schools, which happen to be English-medium?

      Are English-medium schools higher quality?

2. Why are enrollment rates of boys in lower-castes not catching up? Why just girls?

   Lower incomes (tuition: 949 vs. 2,176 rupees in 2001), lower pre-school human capital? discrimination?

Some of the answers in the role of caste and gender in the labor markets of urban areas of India.

A. Castes tend to specialize in occupations.

Lower castes predominantly in blue-collar jobs (e.g., mill workers, government trash collectors).

Upper castes in professional occupations (white collar).

B. Specialization by caste characterizes men, not women.

C. Castes provide services of network: job referrals.

Importance of referrals differs by occupation.

Outline

1. Describe caste model: role of employment networks and network externalities.

2. Test implications of the model

    A. School choice: Does caste play a role in choice of English-medium schools?

    B. School selectivity: What are the effects of caste and rise in return to English on the quality of students in English- and Marathi-medium schools.

3. Examine alternative explanations for caste effects on school choice: income, parent schooling, unmeasured caste ability.

Caste-Based Competitive Employment Model (Free Mobility)

Set-up

1. Two types of jobs:

A. Blue-collar ("high-referral" sector with network externality):

a. inability to discern productivity so that employers pay expected productivity

b. $W_{ij}^{B} = P_{j}^{B}$, where P_{j}^{B} = proportion of persons in *jati* j in blue-collar jobs

B. Professional:

a. $W_{ij}^{P} = \omega_{ij}\theta$, where ω_{ij} = ability of individual i in *jati* j; θ = returns to ability

b. English necessary, so θ = return to English

2. Three ability-types of workers, equally distributed across *jatis*:

P_L, P_M, P_H = proportions low, medium, high ability in each *jati*

3. Each individual lives two periods; chooses schooling type - Marathi or English - in the first period based on expected occupation he/she will be in second period to maximize net expected return (Marathi education less expensive)

Proposition 1 (static economy): 3 equilibria possible for each *jati*; *jatis* can differ persistently in schooling choices, with no change in θ

Example: pre-reform $\theta<1$; $\omega_L = 0$; $\omega_M = 1/2$; $\omega_H = 1$

Three equilibria: (i) Everyone in *jati* chooses Marathi schooling; $W_j^B = 1 > W_{Hj}^P = \theta$

(ii) Only high-ability types choose English schooling

sustainable when $\theta/2 < P_L + P_M < \theta$

(iii) Only low-ability types choose Marathi schooling

sustainable when $P_L < \theta/2$

Proposition 2 (dynamic economy): all *jatis* converge to equilibrium 3 *sequentially*

Post-reform $\theta \geq 1$

At $\theta = 1$: all equilibrium -1 *jatis* move to equilibrium 2, as high-ability types switch to English schools and professional jobs

For $\theta \geq 2(P_L + P_M)$: all *jatis* move to equilibrium 3

Dynamic implications for school selectivity:

1. Students in English-medium schools always higher ability than those in Marathi schools.

2. Average ability declines in Marathi schools as θ increases.

3. Average ability declines in Marathi schools as θ increases more among the *jatis* concentrated in the blue-collar jobs.

4. Changes in the average ability in English-medium schools is ambiguous:

   Example: Initially, (θ=1), average ability in English schools rise (because only high-ability types switch)

   At higher levels of θ ($\theta \geq 2(P_L + P_M)$), average ability in English schools decline.

Optimal and Sub-optimal Caste Restrictions on Mobility

Assume *jati* maximizes average wage W of it members

Thus, in equilibrium 1, $W^1 = 1$ for all values of θ

Examples:

A. for $\theta = 1$ and free mobility, *jatis* in equilibrium 1 move to second equilibrium, then

$$W^2 = (P_L + P_M)^2 + P_H$$

but, $W^2 < W^1$: *jati* welfare declines, creating incentive for caste-based restrictions on mobility (preserve integrity of network)

Social restrictions on mobility *welfare-enhancing and efficient*

B. for $\theta \geq 1 + P_L + P_M$ and free mobility, $W^2 > W^1$, *jati* welfare increases

At some point, social restrictions on mobility *reduce jati* welfare and efficiency

Empirical question: do we see caste-based restrictions on mobility in blue-collar *jatis*, and thus non convergence, due to network externalities in the labor market?

Data: 2002 Dadar, Mumbai Student Survey

1. Random sample of 4700 student records for students residing in the 29 schools in Dadar:

    A. Enrolled in grades 1 through 10 in fall 2001 or

    B. Enrolled in grade 10 over the period, from 1982-1991.

    Thus, covers enrollment decisions over the period 1982-2001.

2. In-home interviews of parents of students completed February 2002.

    A. Information on parents, grandparents, siblings - *jati*, earnings histories, schooling, occupation, how found job

3. Information on schools from school principals:

    scores on secondary-school-leaving exams for students, medium of instruction, class sizes, teacher qualifications, facilities.

English is the medium of instruction in 10 schools

Marati (local language) in 19.

59 *jati*s represented, 15% in upper castes

Table 1
Secondary Student Quality and School Quality in Dadar, by School Language of Instruction

School type	English Medium	Marathi Medium	Difference
Student exam results (1998-2001)			
Percent passed	92.3 (6.19)	52.5 (24.6)	39.8 (t=6.33)
Percent first class among passed	36.4 (5.38)	24.7 (13.8)	11.7 (t=3.02)
Percent distinction among passed	25.3 (12.3)	7.16 (7.77)	18.2 (t=4.00)
School characteristics			
Student-faculty ratio	36.7 (7.60)	35.8 (8.96)	0.956 (t=0.28)
Class size	61.9 (3.69)	62.3 (3.16)	-378 (t=0.08)
Students per desk	2.40 (0.316)	2.36 (0.479)	0.039 (t=0.23)
Proportion of teachers with B.Ed.	0.725 (0.221)	0.701 (0.203)	0.024 (t=0.28)
Proportion of teachers with higher degree	0.0786 (0.0925)	0.0971 (0.147)	-0.0185 (t=0.36)
Computers per student	0.0174 (0.0138)	0.0176 (0.0192)	-0.0002 (t=0.03)
Number of schools	10	18	28
Enrollment per school	1528	1029	

Percent of Men Receiving Job Referrals and Speaking English, by Occupation

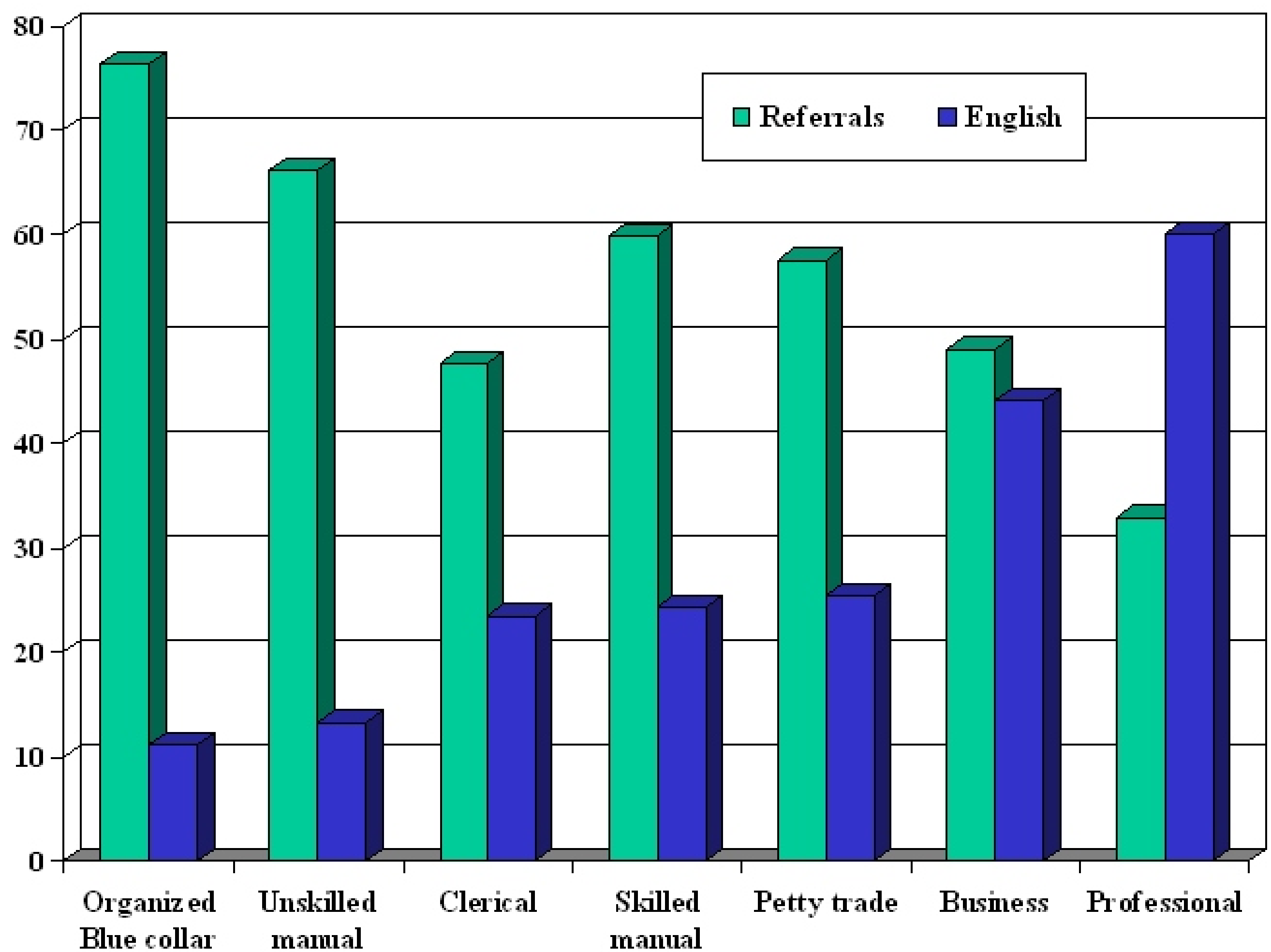


Table 1
Occupational Distribution (%), by Caste and Generation: Mumbai Men

Relationship to Student	Fathers (2002)			Grandfathers (1980)		
Occupation	Low Castes	Middle Castes	High Castes	Low Castes	Middle Castes	High Castes
No work	2.63	2.69	0.94	1.13	1.15	0.72
Unskilled manual	11.1	7.84	4.41	9.00	3.63	2.10
Skilled manual	17.4	13.7	10.2	11.67	6.72	8.42
Organized blue collar	**22.9**	**19.2**	**2.90**	**22.9**	**24.2**	**7.67**
Clerical	28.1	36.6	20.8	22.2	23.8	28.4
Professional	**8.30**	**8.79**	**43.5**	**5.56**	**6.18**	**33.7**
Business	7.95	8.79	15.2	6.11	4.72	13.0
Petty trade	4.00	4.51	2.52	3.11	3.20	3.34
Farming	0.33	0.48	0.12	19.4	27.5	2.97
Number	1860	1774	793	1866	1934	839

Table 2
Occupational Distribution (%), by Caste: Mumbai Women

Occupation	Low Castes	Middle Castes	High Castes
No work	79.7	80.5	49.1
Unskilled manual	6.06	3.24	1.18
Skilled manual	1.81	1.60	3.17
Organized blue collar	**0.90**	**1.03**	**0.35**
Clerical	6.38	7.88	23.4
Professional	3.46	4.53	20.3
Business	0.90	0.51	1.88
Petty trade	0.80	0.72	0.59
Farming	0	0	0
Number	1881	1942	851

Table 3
Determinants of the Choice of English-Medium Schooling, by Gender

Sample	Boys		Girls		All
Variable/estimation procedure	OLS	FE-occup.	OLS	FE-occup.	FE-caste
Jati-level job assistance	-.378 (2.55)	-.334 (2.21)	.116 (0.69)	.169 (1.00)	-
Jati-level job assistance x boy	-	-	-	-	-.404 (5.59)
Age (cohort)	-.0090 (4.51)	-.0112 (6.83)	-.0099 (5.17)	-.012 (5.34)	-.00992 (6.64)
English medium schooling - father	.234 (7.13)	.208 (5.33)	.309 (12.0)	.285 (10.1)	.246 (11.9)
English medium schooling - mother	.211 (7.38)	.175 (6.01)	.263 (5.98)	.240 (6.60)	.232 (7.52)
Years of schooling - father	.0222 (5.63)	.0193 (5.33)	.0199 (6.64)	.0158 (4.85)	.0209 (8.85)
Years of schooling - mother	.0242 (7.21)	.0193 (6.38)	.0262 (8.75)	.0222 (6.84)	.0244 (9.96)
Father's income ($x10^{-5}$)	.566 (1.21)	.271 (0.84)	.818 (2.78)	.601 (3.16)	.557 (1.76)
Boy	-	-	-	-	.253 (6.13)
N	2240	2240	2046	2046	4286

Table 5
Change in School Selectivity by Caste-type, Post-1990 Period:
Student's Father's Schooling

Sample	Boys in Marathi-Medium School		Boys in English-Medium School	
Variable/Estimation procedure	OLS	FE-Caste	OLS	FE-Caste
Age (cohort)	.708 (3.29)	.548 (3.51)	-.331 (2.10)	-.392 (2.49)
Age x caste-level job assistance	-1.43 (3.88)	-1.14 (4.53)	.706 (2.27)	.806 (2.54)
Caste-level job assistance	6.54 (1.58)	-	-15.2 (4.17)	-
Constant	7.63 (3.06)	-	20.4 (10.9)	-

Rates of Out-Marriage (Hindus), by Quinquennia, Mumbai 1970-2002 (N=5,406)

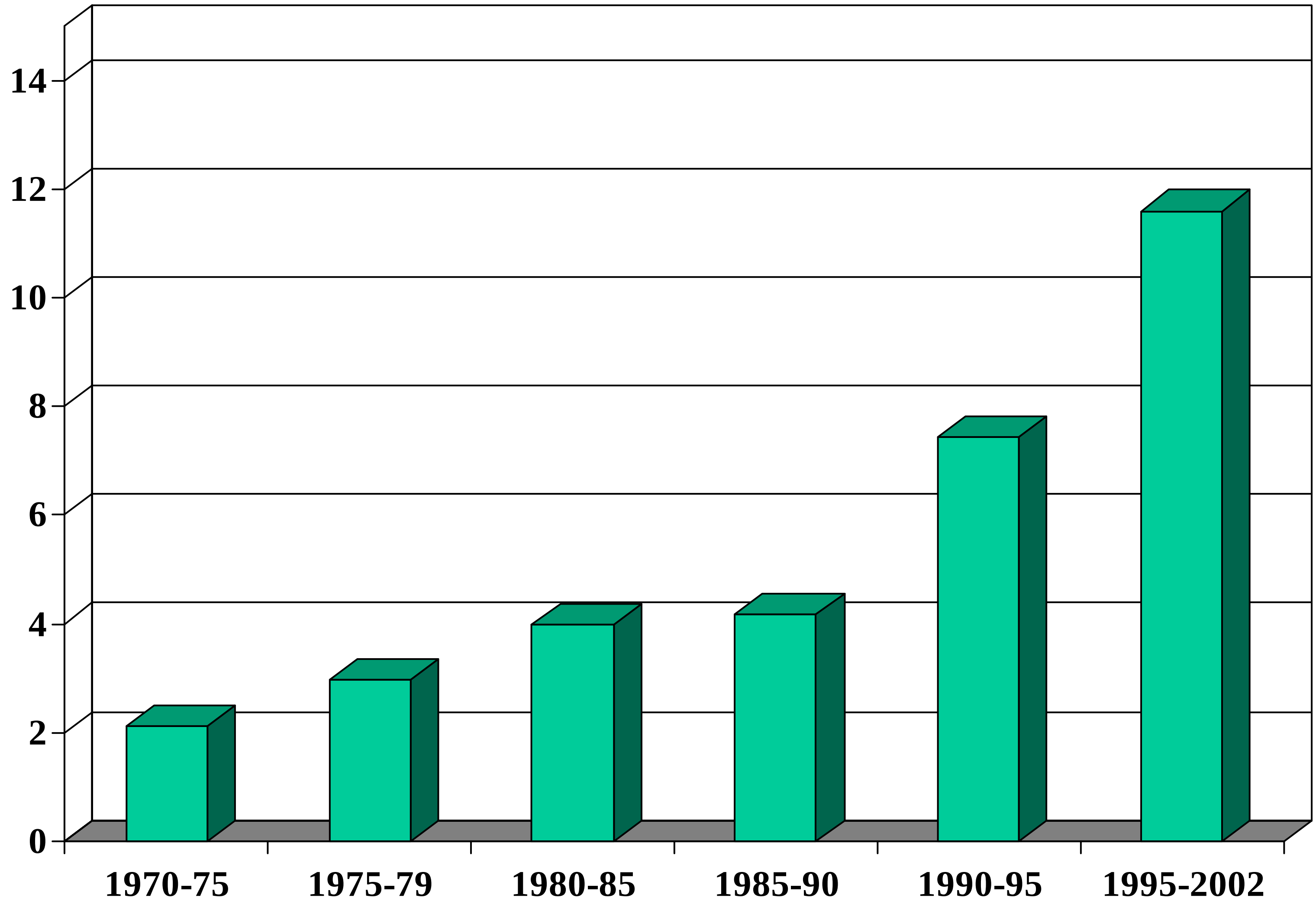


Table 3
Percentage with a Job in the Current Generation, by Caste Group, School Type and Gender: Siblings of Respondent Age 20-35

Caste/gender	Female Siblings (N=137)	Male Siblings (80)
	English-medium Schooling	
Lower caste	50.0	82.8
Middle caste	57.7	77.4
Upper caste	59.2	87.5
	Marathi-medium Schooling	
Lower caste	29.7	76.2
Middle caste	39.2	79.5
Upper caste	52.3	82.5