Economic Development and Agricultural Development

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Three routes to agricultural development (not mutually exclusive):

A. Technological progress

What is impact on agricultural productivity, rural wages?

What is the impact on aggregate economy?

Research: "Green Revolution" in India - new, genetically-modified seeds, 1971 -

B. Improvement in rural financial markets

What is the impact on agricultural produtivity, rural wages?

Research: Random dissemination of weather insurance

C. Land distribution

Research: What is the optimal scale of operation in farming?

How much of this research, based on Indian agriculture, relevant to Colombia?

A. Common features (these are key):

1. Large number of landless rural laborers (1/3 in Colombia).

2. Large number of very small farms.

B. Differences:

1. India: annual crops dominate (rice, wheat) while in Colombia tree crops are important (coffee, bananas)

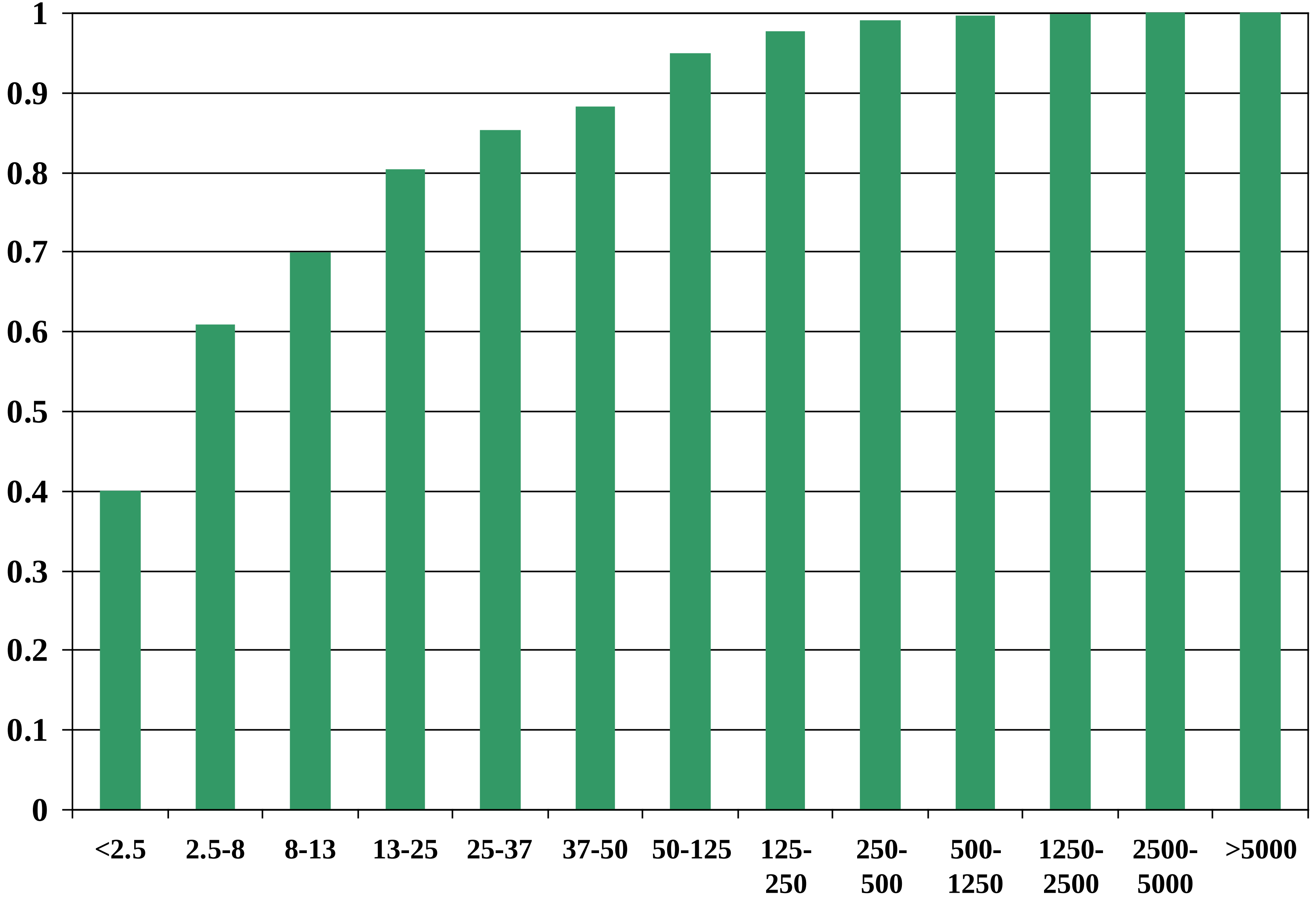
But, large rice sector in Colombia.

2. Very large farms in Colombia absent in India.

3. Property rights in India reasonably secure.

Figure A4. Cumulative Distribution of Owned Landholdings (Acres) in Colombia, 2011

Fuente: Atlas de la distribución de la Propiedad Rural en Colombia. CEDE (UNIANDES)-IGAC-Universidad de Antioquia. 2012.



A. Lessons from the Indian Green Revolution

What was it? Government policy important

1. In the late 1960's, importation of new, high yielding seeds genetically-modified in Mexico and the Philippines: open policy.

2. Government resources used to modify the seeds to make them more suitable for local areas: public R&D research subsidy.

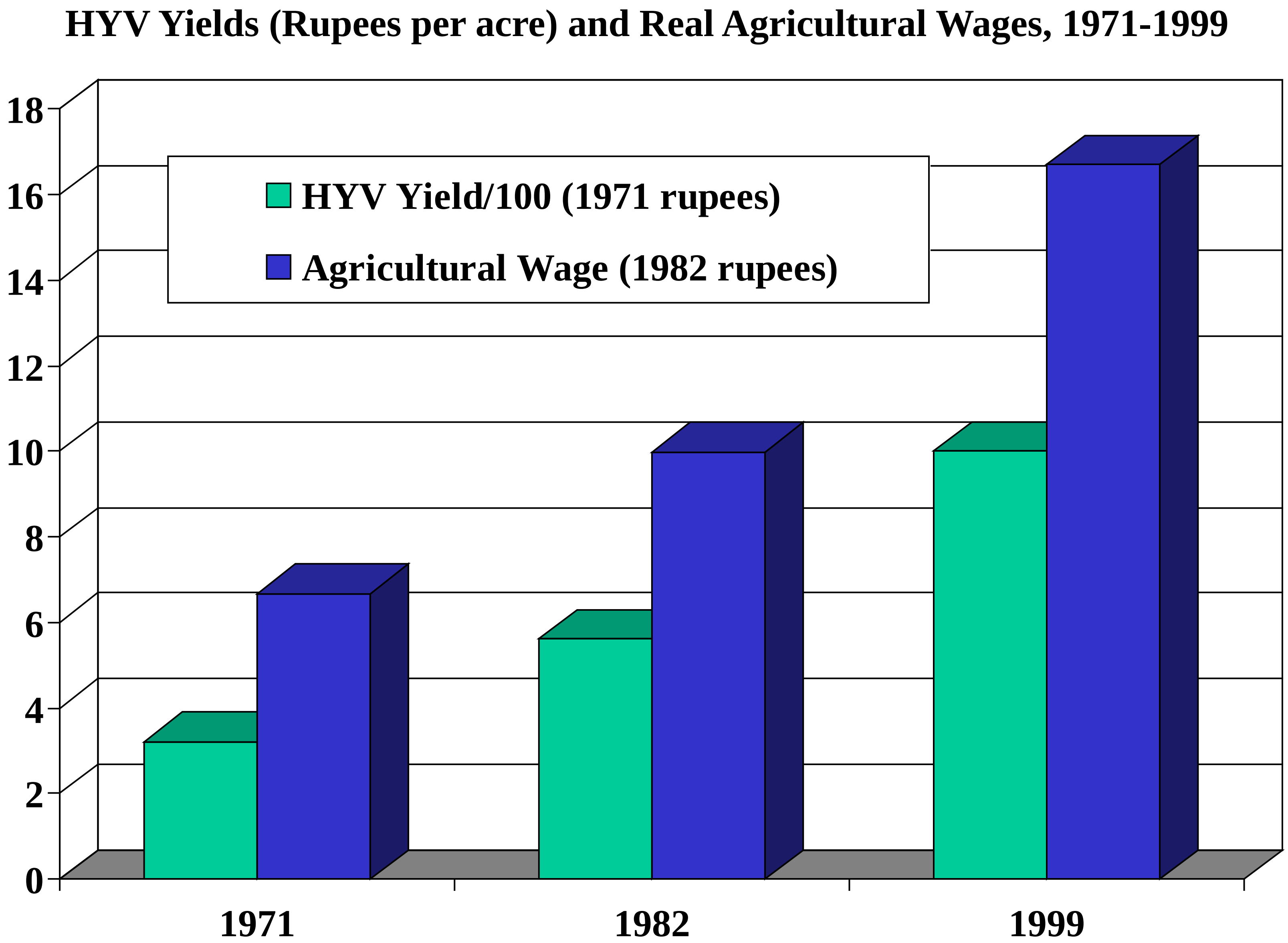
What happened?

Research: Panel data starting at the onset of the revolution for all of India

Who adopted first?

What happened to returns to factors (irrigation, schooling)?

What happened to the size of the rural population and the size of farms?


HYV Yields (Rupees per acre) and Real Agricultural Wages, 1971-1999
HYV Yield/100 (1971 rupees)
Agricultural Wage (1982 rupees)
0
2
4
6
8
10
12
14
16
18
1971
1982
1999

Research on the Indian Green Revolution (Foster and Rosenzweig, 1995, 1996)

1. Used two panel data sets covering all of rural India:

    A. 1968-1971 panel, right at the onset of the change

    B. 1971-1982 panel

2. Estimates obtained of:

    A. The use of HYV, by farmer schooling and land holdings size.

    B. The initial profitability of HYV use, by schooling and irrigation.

    C. The effects of technical change on the returns to schooling, labor and farm assets (e.g., irrigation assets)

    D. Rates of technical change by area (districts, villages)

Inputs, including HYV use, endogenous variables

1. Did *users* of new seeds with more schooling benefit more?

Use the HYV-conditional (on HYV seed use) profit function Π^h:

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

$$\max_{L_t, L'_t, F_t, F'_t} [H_t[q(\theta_t, S_t, L_t, F_t; \mathbf{A}_t, \mu, \epsilon_t) - w_t L_t - p_t F_t] + (\lambda - H_t)[q'(\theta'_t, S_t, L'_t, F'_t; \mathbf{A}_t, \mu, \epsilon'_t) - w_t L'_t - p_t F'_t]$$

where

H_t = HYV seed use

w_t and p_t = the prices of labor and fertilizer, respectively

λ = the total amount of land cultivated

primes (') denote old (traditional) technology values

What is the difference between the contributions of schooling to output under the traditional and new technologies?

(2) $$\partial^2 \Pi_t^h / \partial H_t \partial S_t = \partial q_t / \partial S_t - \partial q'_t / \partial S_t$$

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 returns to assets 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:

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

$+ \Sigma\alpha_F\tau_{jt}p_t + \Sigma\beta_\epsilon\Delta\epsilon_{ijt} + \Sigma\alpha_\epsilon\tau_{jt}\epsilon_{ijt},$

where

$\Delta\pi_{ijt} = \pi_{ijt} - \pi_{ij0}$, $\tau_{jt} = \Delta\theta_{jt} = \theta_{jt}$ (because θ_0=0) = area-specific technology 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)

NCAER ARIS-REDS Sample Villages

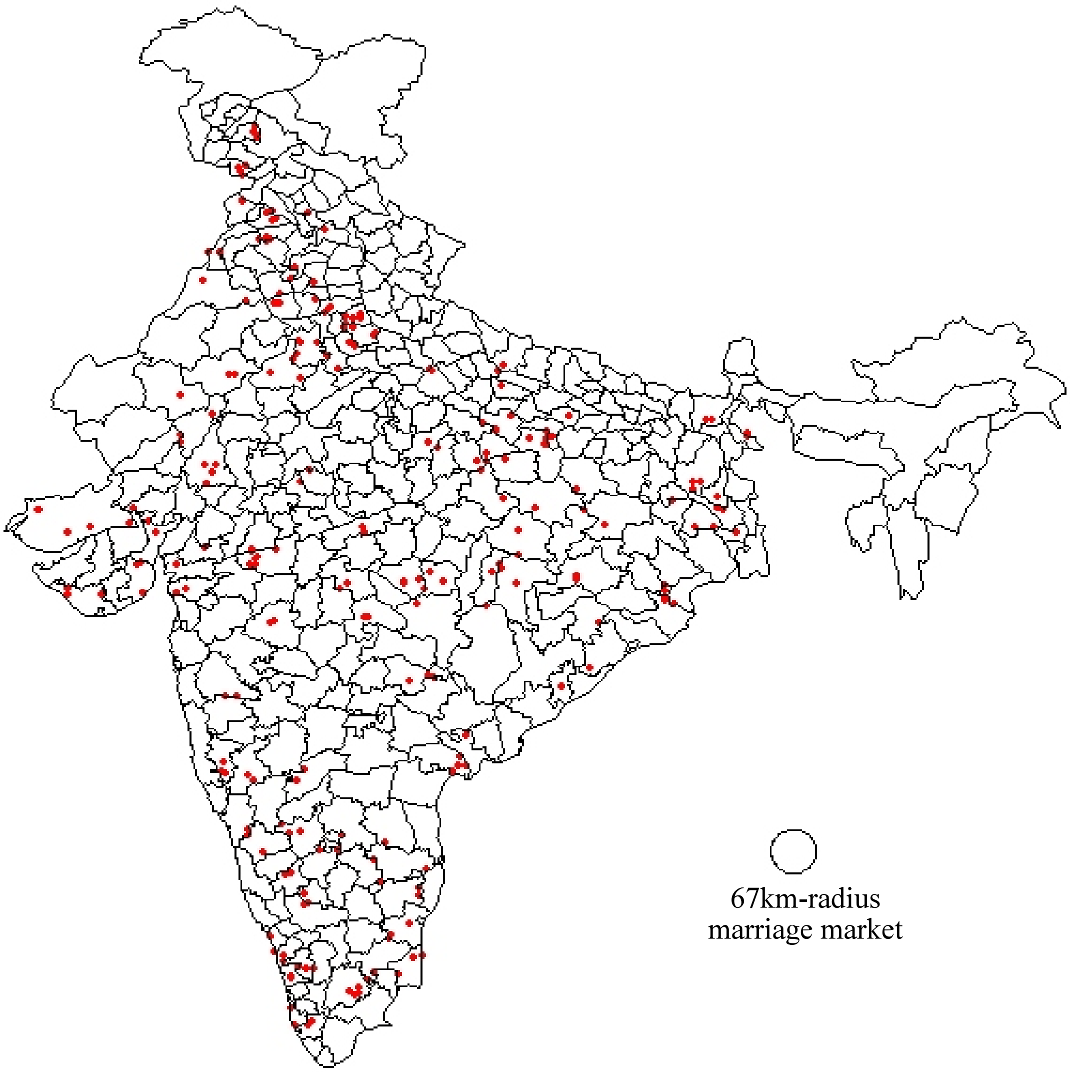


Table 1
Determinants of HYV Adoption by 1971:
Farm Households in HYV-Using Districts

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

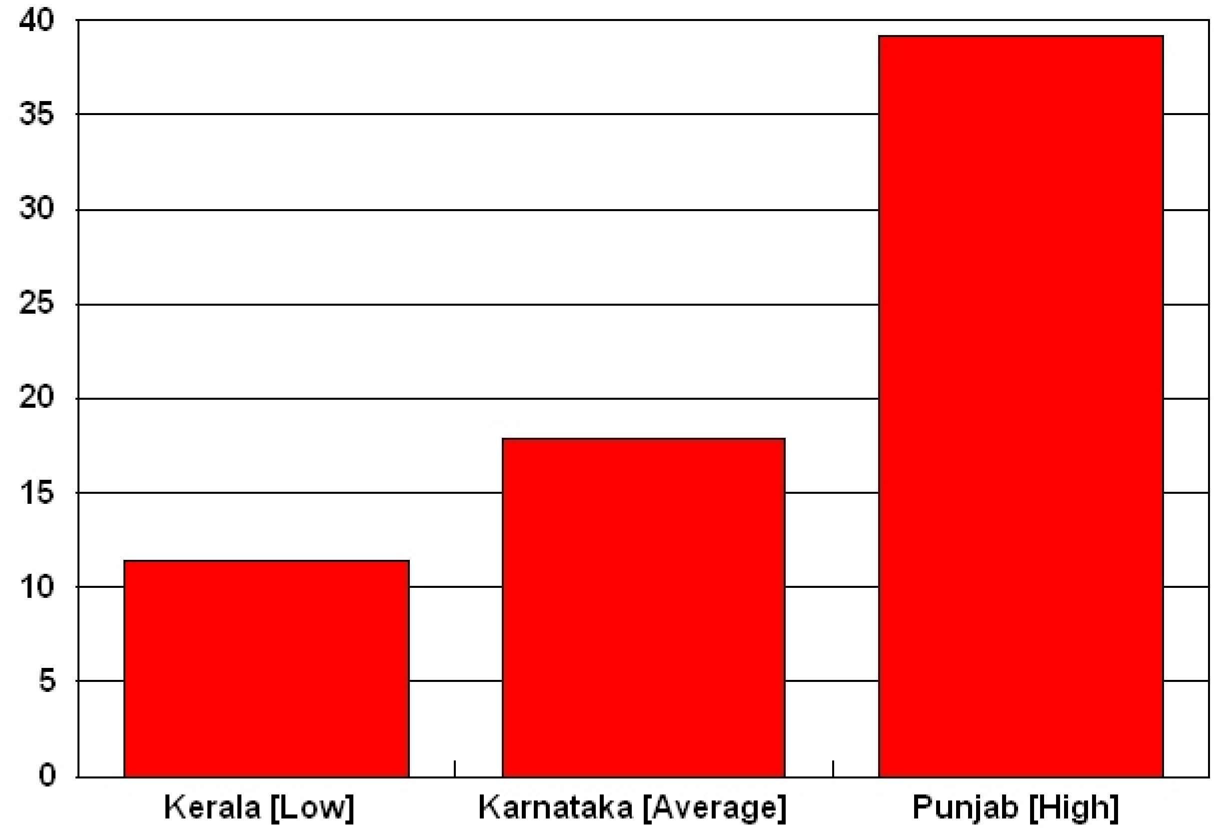
Variable\Est. meth.	FE-IV[a]	FE-IV[a]
HYV acreage	722	-10100
	(0.65)[c]	(3.53)
HYV×schooling	--	7650
		(3.07)
HYV×proportion land irrigated	--	6130
		(2.54)
Farm equipment	4.21	2.37
	(2.51)	(1.16)
Irrigation assets	.768	.273
	(1.73)	(0.54)
Other farming assets	5.40	8.21
	(2.69)	(3.30)
Adverse weather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

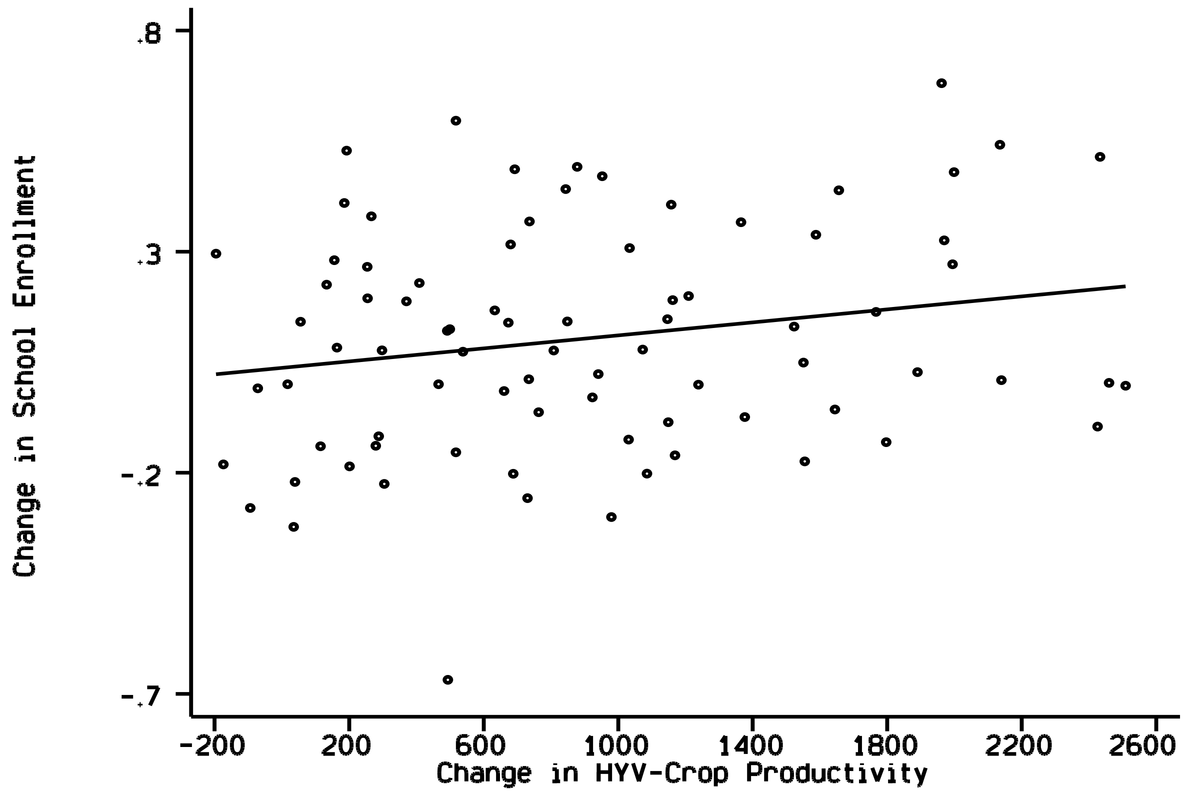
Table 4
Non-Linear FE-IV Estimates: Conditional Profit Function
with District-Specific Growth Intercepts, 1971 - 1982

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



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



Technological change in agriculture:

A. Supportive role of government: remove barriers, R&D

B. Substantial, real advances in productivity and rural wages.

C. In technologically advancing agriculture, schooling plays an important role.

D. Larger farms with irrigation benefit most.

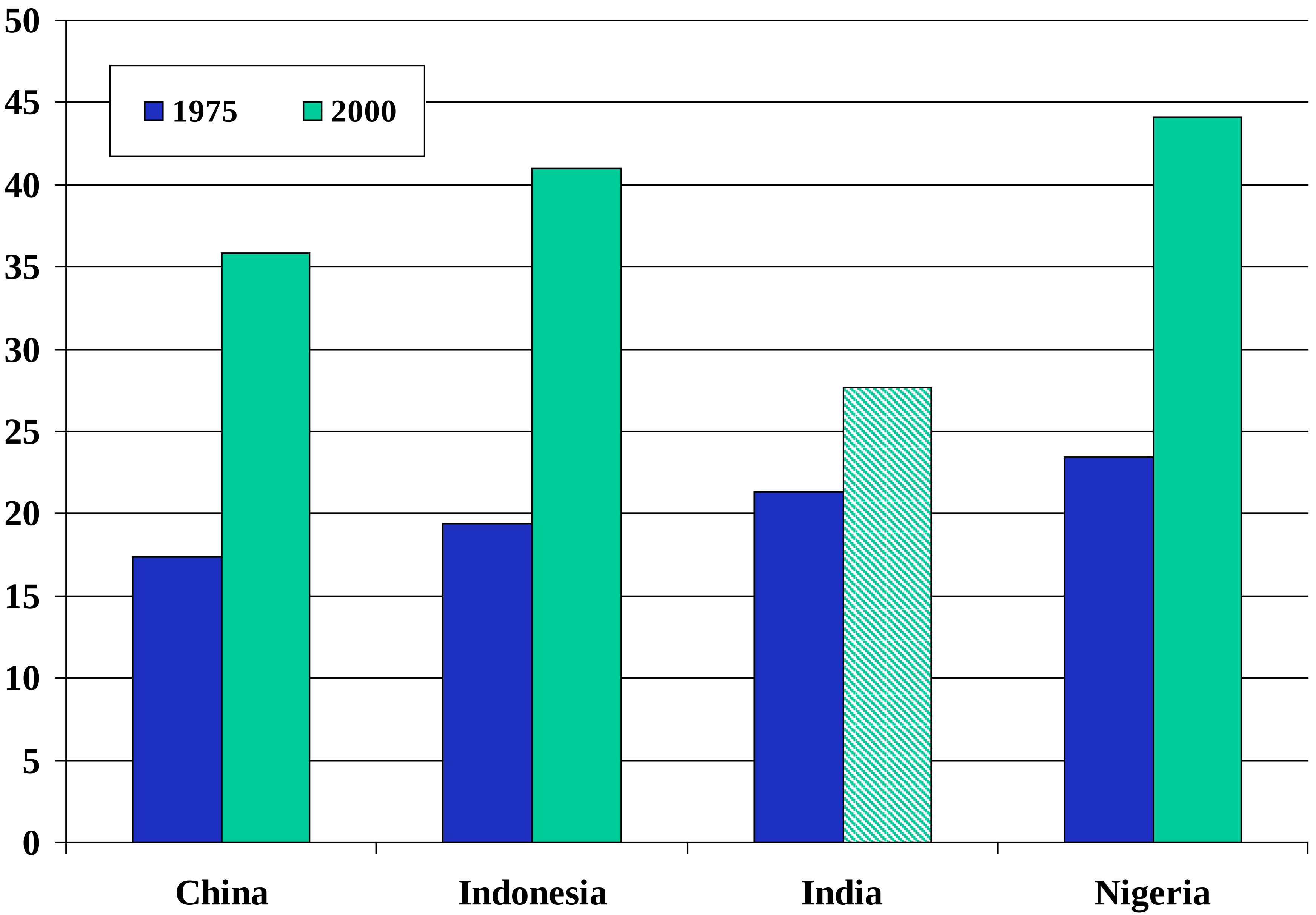
E. But, no change in farm scale, little out-migration. No change in industrialization.

Why?

A. Informal risk-sharing in rural areas; no public safety net (Munshi and Rosenzweig, 2014)

B. Lack of industrialization.

Figure 1. Change in Percent Urbanized, by Country, 1975-2000



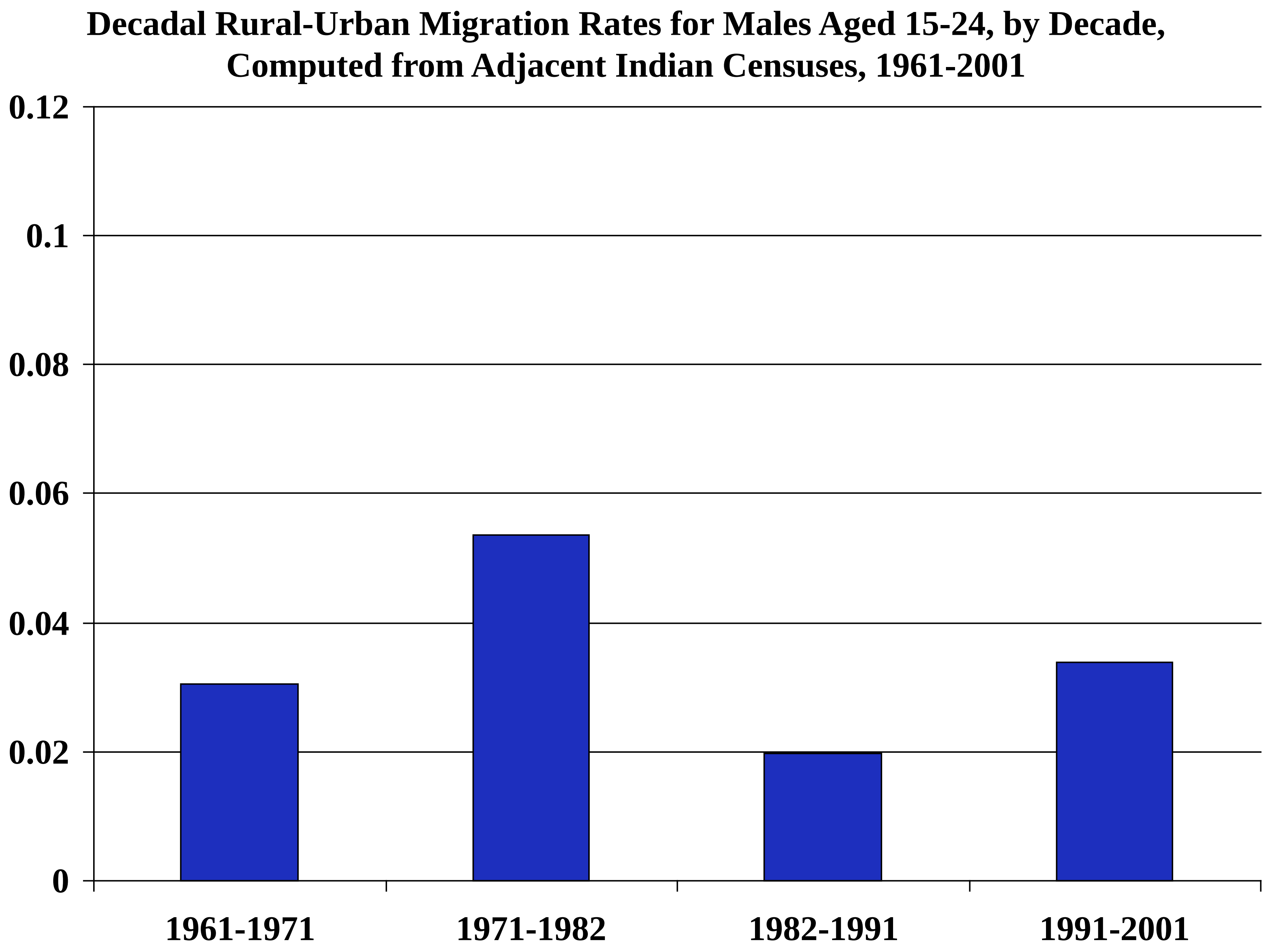
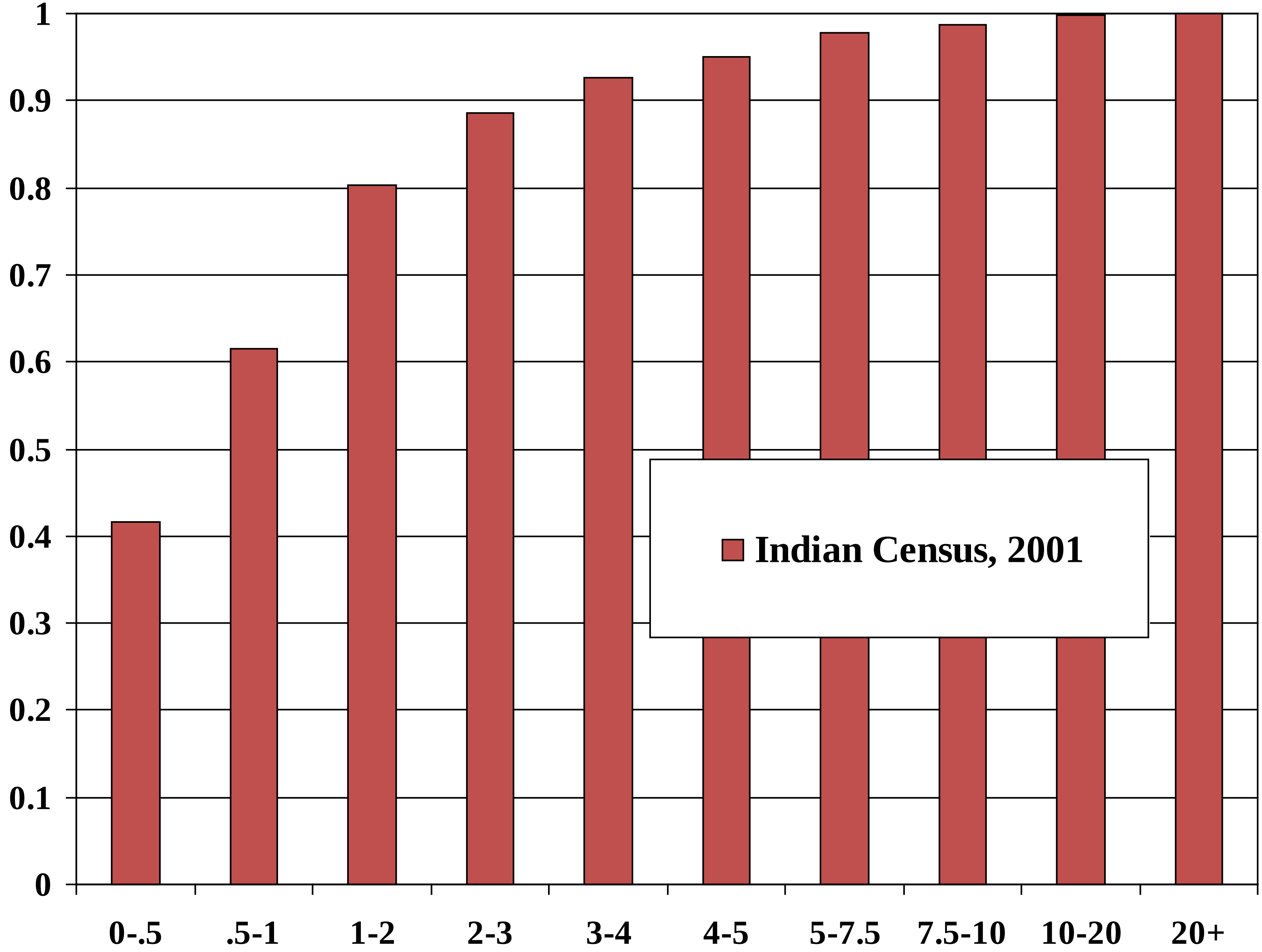

Decadal Rural-Urban Migration Rates for Males Aged 15-24, by Decade,
Computed from Adjacent Indian Censuses, 1961-2001
0.12
0.1
0.08
0.06
0.04
0.02
0
1961-1971
1971-1982
1982-1991
1991-2001

Figure A3. Cumulative Distribution of Owned Landholdings (Acres) in India



B. Improvement in financial markets.

Farming is a risky activity, for farmers and for rural workers.

Dependent on rainfall, subject to pest infestation.

Evidence that risk leads to farmers acting conservatively: sacrifice high returns for more certain returns.

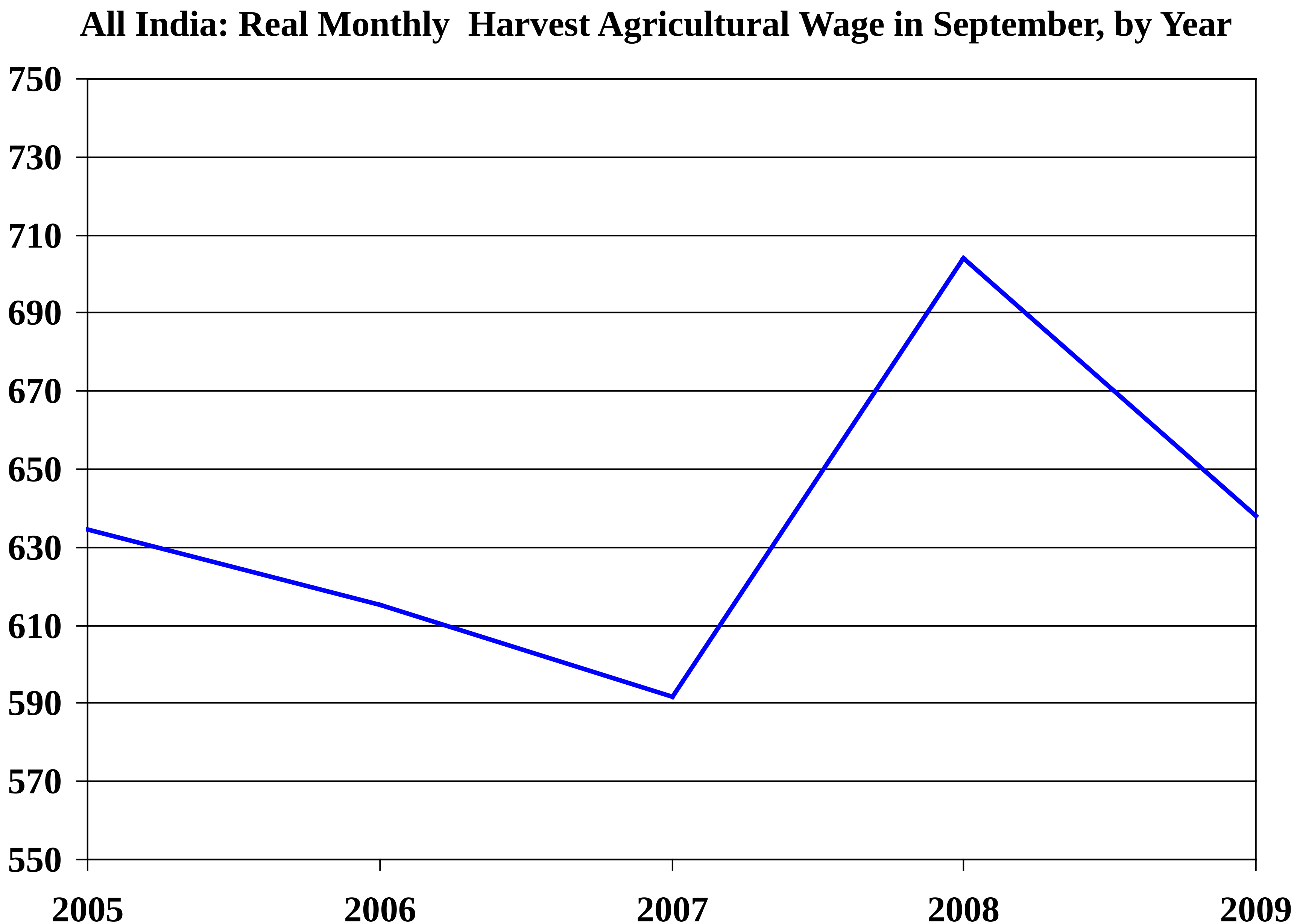
New evidence from randomly-controlled trials (RCTs) of the impact of the provision of weather insurance.

Payoffs depend on rainfall, not farmer actions, so no adverse moral hazard effects on insurer profitability (which would bar provision).

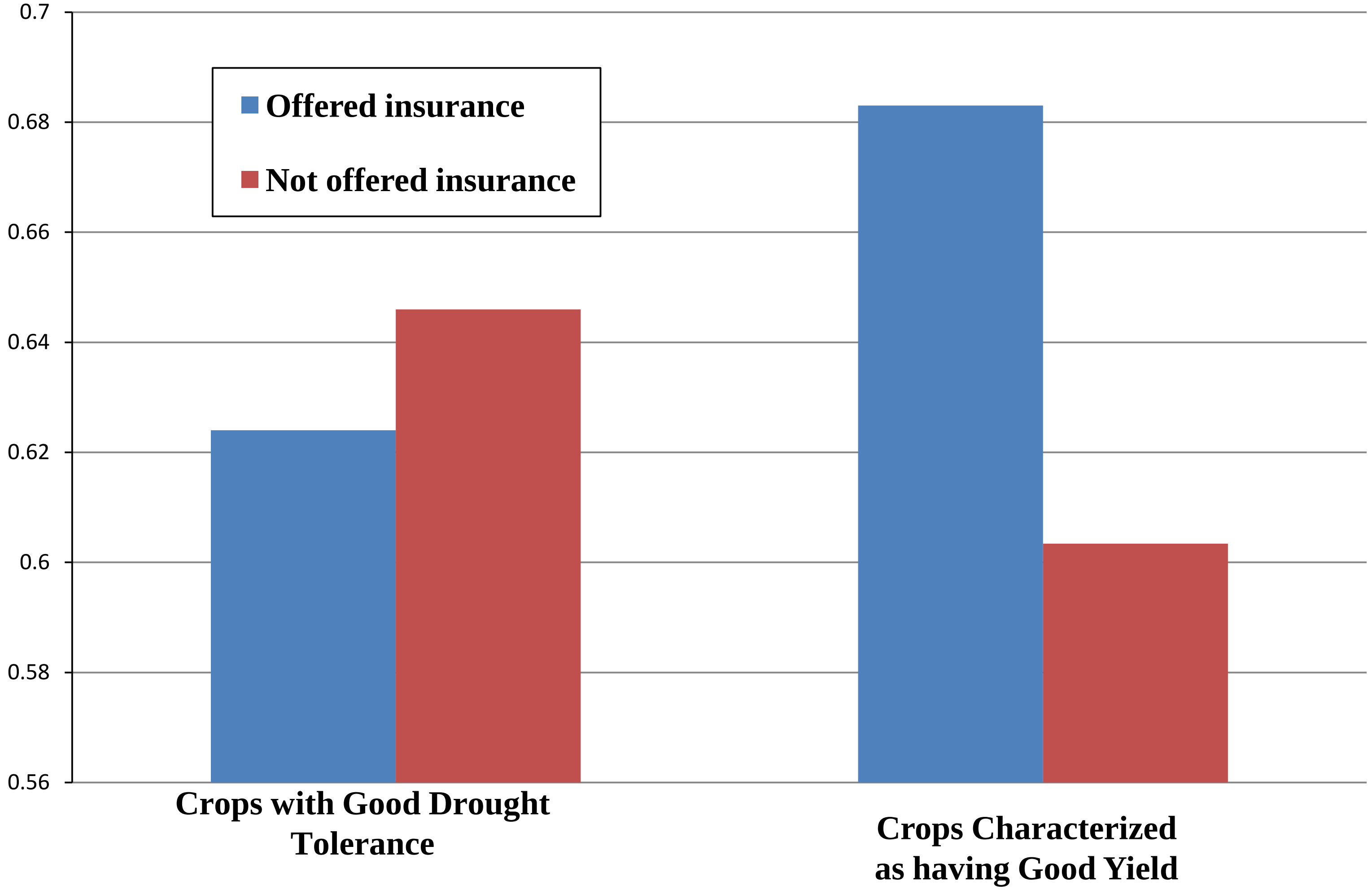
Evidence: (India and Ghana) Farmers take more risk and have higher productivity; under-investment reduced

But what is the impact on landless agricultural workers?

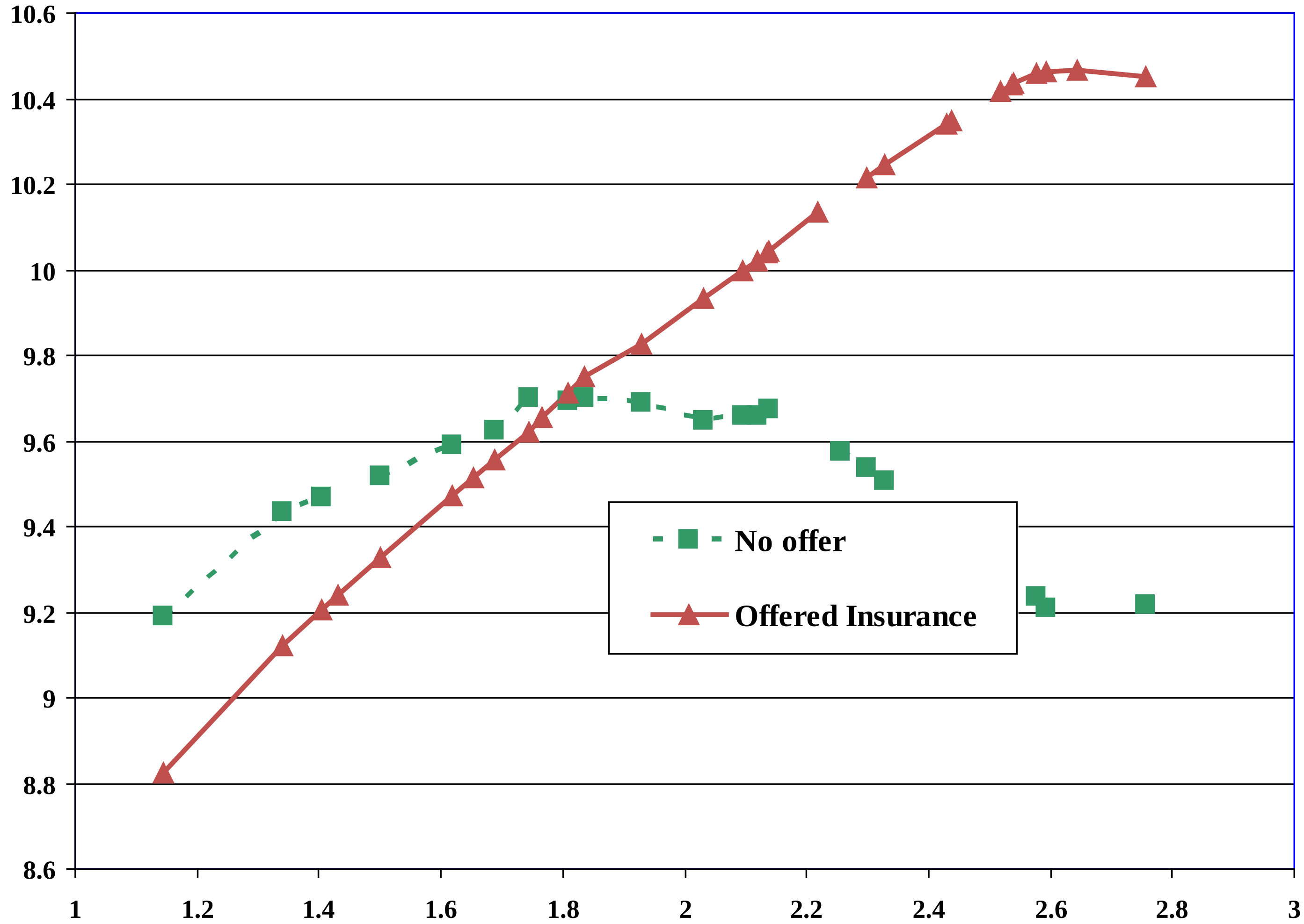
More variability in output could mean more volatile wages


All India: Real Monthly Harvest Agricultural Wage in September, by Year
750
730
710
690
670
650
630
610
590
570
550
2005
2006
2007
2008
2009

When offered Insurance (ITT from RCT experiment), farmers in Tamil Nadu switch to high-risk, high-return varieties of rice



With Insurance, Cultivator Output becomes more responsive to rainfall variation



Lowess-Smoothed Relationship Between Log Per-Acre Output Value and Log Rain per Day in the *Kharif* Season, by Insurance Type and Level

Research on the general-equilibrium effects of insuring farmers and landless laborers (Mobarak and Rosenzweig, 2014)

A. Randomly offered heavily-subsidized rainfall insurance product to cultivators and landless laborers in 60 villages in three states in India.

B. Proportions of each group offered insurance sufficiently large to have general-equilibrium effects in each village

Little migration between villages in peak season (tested)

C. Modeled effects on labor demand , labor supply and effects on equilibrium wages

D. Tests of insurance effects on harvest labor demand, labor supply and on agricultural wage rates

E. Key findings: 1. Offering insurance only to landed cultivators increases wage volatility and lowers wages in bad rainfall states compared with no insurance.

2. Offering insurance to landless reduces wage volatility.

Landless Labor Households, Labor Supply and Rainfall Insurance

$U = h^{\gamma} c^{(1-\gamma)}$

h=leisure; *c*=consumption good traded internationally
Labor markets are local (village) during Kharif (little migration)

There are two stages of nature, L and H

The L-state occurs with probability q

Insurance costs *p* per unit and pays out I

$$c^L = w^L(1-h) + m - pI + I$$

$$c^H = w^H(1-h) + m - pI$$

where m = non-earnings income,

$1 - h = l^s$ (Labor Supply)

$$\underset{I,h}{\text{Max}}\, E(U) = qU^L + (1-q)U^H$$

$FOC: \quad q(1-p)U_c^L = p(1-q)U_c^H$ (U_c^L=U_c^H if actuarially fair.)

Table 1

Insured and Uninsured Landless Labor Supply in the *H* and *L* States		
State of nature	*L* (Payout)	*H* (No Payout)
Insured labor supply	$1 - \gamma - \dfrac{\gamma(m + (1-p)I)}{w^L}$	$1 - \gamma - \dfrac{\gamma(m - pI)}{w^H}$
Uninsured labor supply	$1 - \gamma - \dfrac{\gamma(m)}{w^L}$	$1 - \gamma - \dfrac{\gamma(m)}{w^H}$
Difference insured and uninsured	$\dfrac{-\gamma(1-p)I}{w^L}$	$\dfrac{\gamma pI}{w^H}$

Key Labor Supply Result

- **Proposition 1**: Labor supply of insured and uninsured varies with respect to whether payouts occur:
  - In the bad state, insured labor supply is lower (they get payouts, and have less need for income)
  - In the good state, insured labor supply is higher (they have paid the premium)
- Empirics: we will have variation in both insurance offers and payouts
  - Insurance premiums are subsidized, but payouts are large in relative terms

Cultivator Households, the Demand for Labor and Insurance

Production takes place in stages:

In stage 1, cultivators decide on the stage-1 technology α, choosing between the most conservative, lowest-yielding technology ($\alpha = 0$) and the most profitable and riskiest technology ($\alpha = 1$), and whether to take insurance

In stage 2, the state of nature θ^j is realized, labor is hired and profits are maximized given the technology chosen in stage 1

Stage-2 output in state $j = (1 - \alpha) + \alpha\theta^j$

where θ^j = 0 in the L state

= κ in the H state

and $(1- q)\kappa > 1$

Labor demand is *Leontief*, with δ units of labor required per unit output

The stage-1 program:

$$\max_{\alpha, I} E(U) = U(c_1) + b[qU(c_2^L) + (1-q)U(c_2^H)]$$

$$c_1 = m - s - pI$$

$$c_2^j = rs + [(1 + \alpha(\theta^j - 1)][p - \delta w^j] + \iota^j I$$

where $\iota^j = 1$ if $j=H$

$\iota^j = 0$ if $j=L$

S= savings, r=savings return, p=output price

$\alpha = 1$ is the choice that maximizes *expected* profits

Standard result: $\alpha < 1$ given risk aversion and uncertainty

*Proposition 3: α is higher the lower the cost of insurance (lower for the uninsured)

Labor Market Equilibrium in any state j

$$1 - \gamma - \gamma y^j/w^j \quad = \quad \delta[(1 + \alpha(\theta^j - 1)]$$

$$\text{so} \quad w^j = \gamma y^j/[1 - \gamma - \delta[(1 + \alpha(\theta^j - 1)]]$$

Proposition 4: Offering insurance to landless laborers dampens wage volatility.

Proof: The effect of an increase in y on the equilibrium wage is always positive:

$$dw^L/dy = \gamma/[1 - \gamma - \delta(1 - \alpha)]>0, \text{ for } w^L>0$$

$$dw^H/dy = \gamma/[1 - \gamma - \delta(1 + \alpha(\kappa - 1))]>0, \text{ for } w^H>0$$

In state L, y is higher for the insured (l^s lower), so w^L increases.

In state H, y is lower for the insured (l^s higher), so w^H decreases.

Offering insurance to some landless smooths income for the uninsured landless.

Proposition 5: Offering insurance to cultivators increases average wages.

Proof: Insured cultivators choose a higher-α technology (Proposition 3). The effect of an increase in α on the *expected* equilibrium wage is positive.

$$dE(w)/d\alpha = \delta\gamma[(1 - q)\kappa - 1]E(y)/ [1 - \gamma - \delta[(1 + \alpha((1 - q)\kappa - 1)]]^2 > 0$$

Proposition 6: Offering insurance to cultivators increases wage volatility (Δw) and makes the uninsured landless worse off in the L state.

Proof: The effect of an increase in α on wages in the H state is positive. The effect of an increase in α on wages in the L state is negative.

$$dw^L/d\alpha = -\gamma\delta y/[1 - \gamma - \delta(1 - \alpha)]^2 < 0$$

$$dw^H/d\alpha = (\kappa - 1)\gamma\delta y/[1 - \gamma - \delta(1 + \alpha(\kappa - 1))]^2 > 0$$

Offering insurance only to cultivators may worsen the welfare of the (uninsured) landless.

Delayed Monsoon Onset Insurance Product

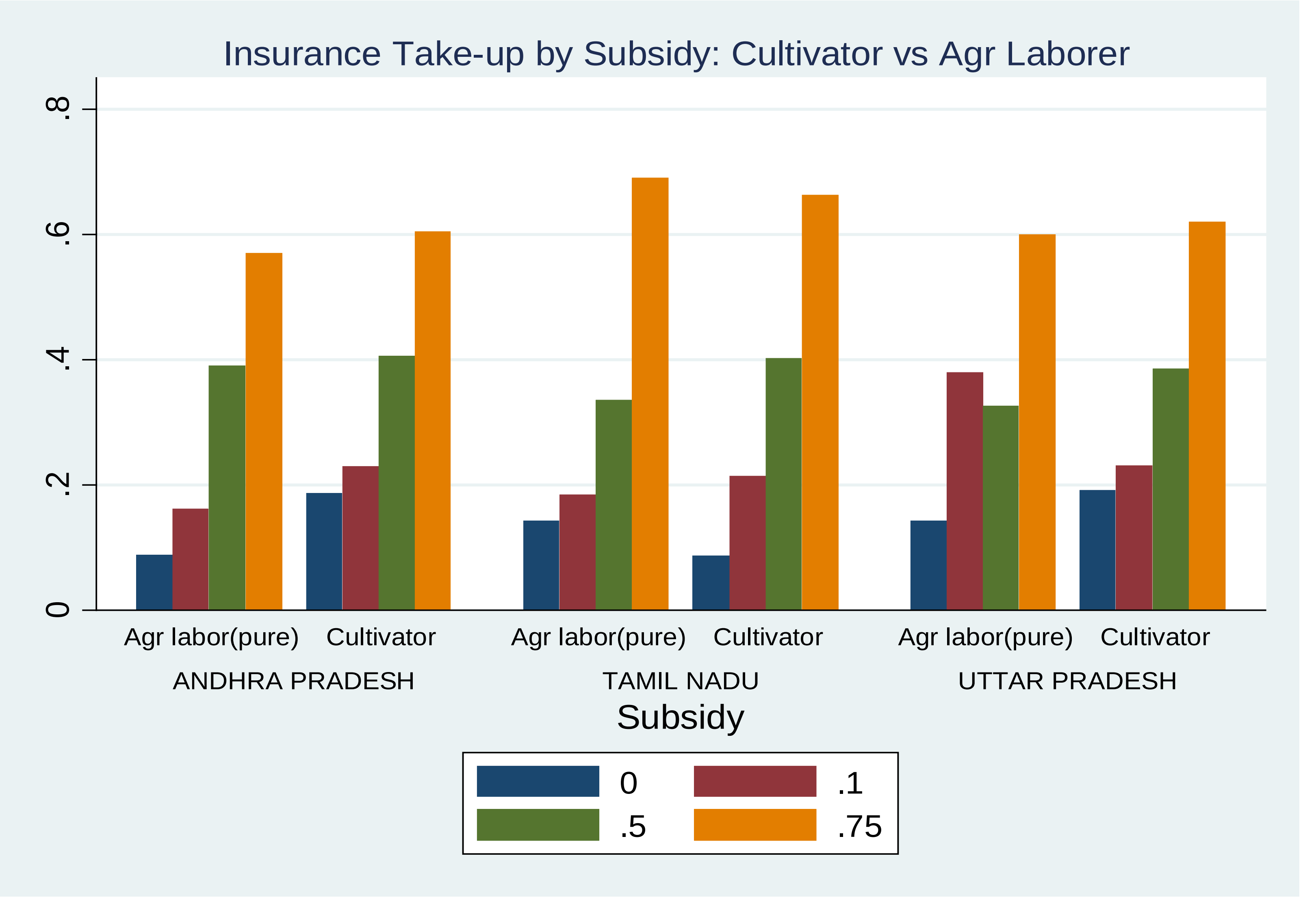
Agricultural Insurance Company of India (AICI)

AICI offers area based and weather based crop insurance programs in almost 500 districts of India, covering almost 20 million farmers, making it one of the biggest crop insurers in the world.

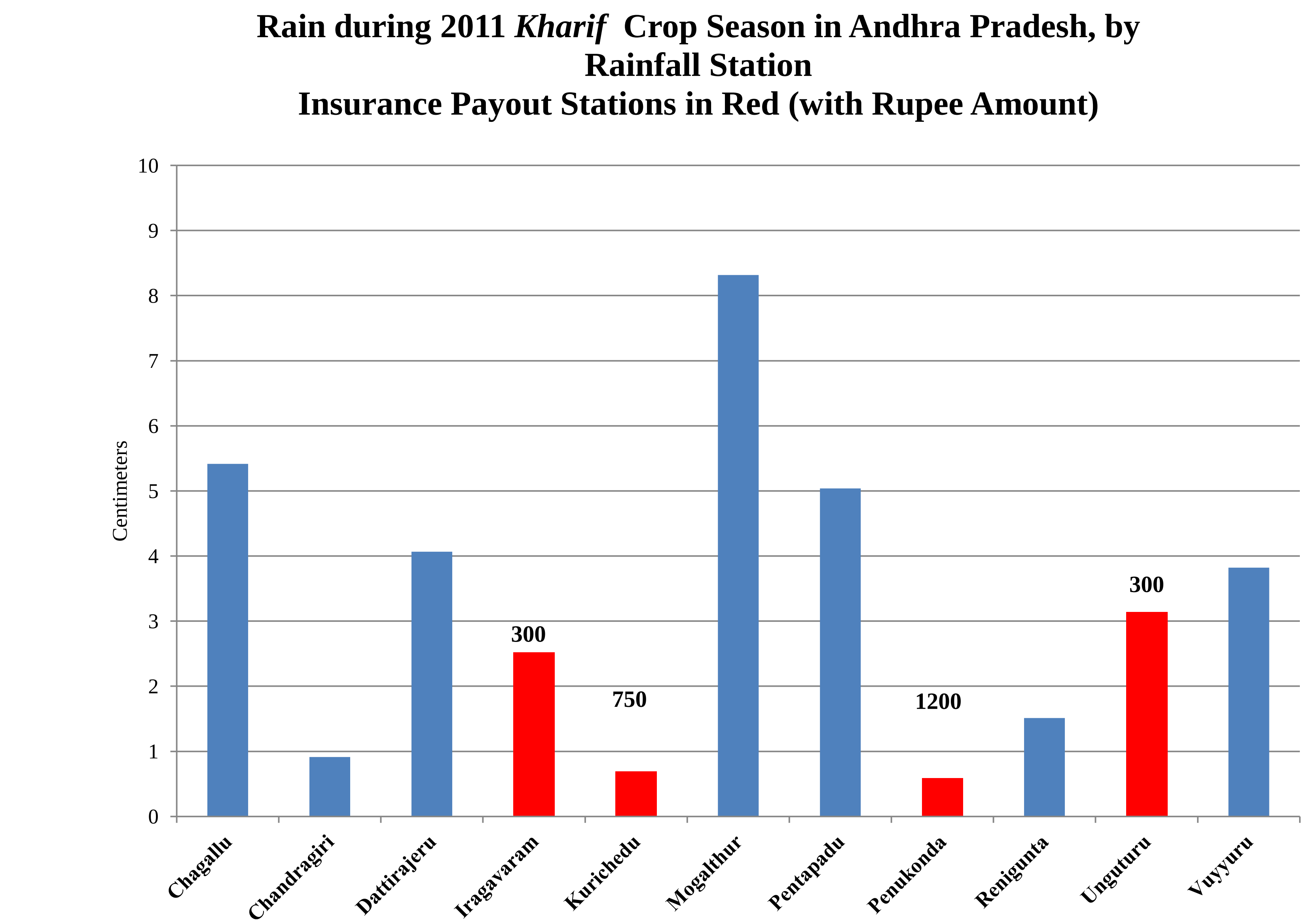
Timing and Payout Function

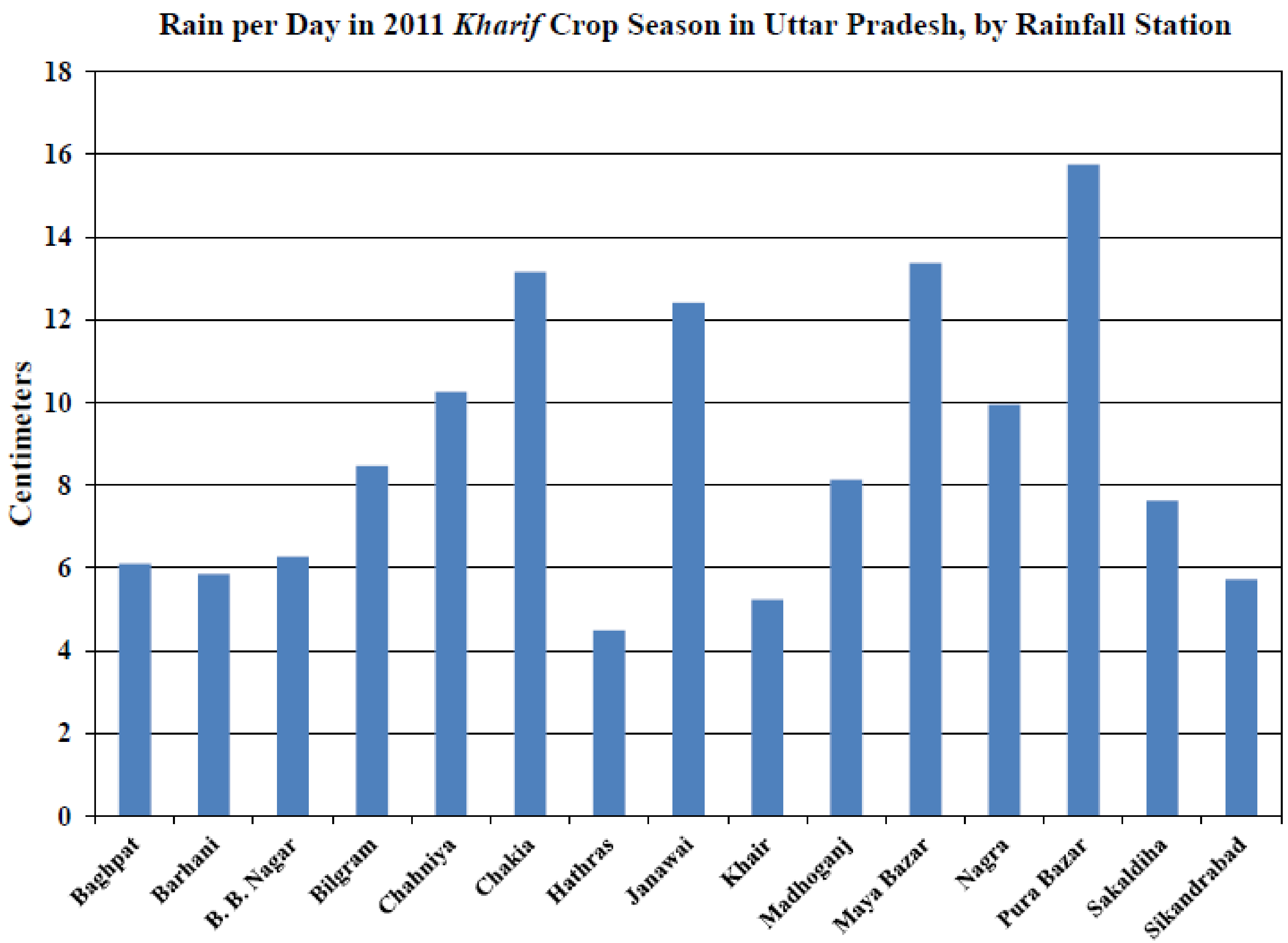
Trigger Number	**Range of Days Post Onset** (varied across states and villages)	**Payout** (made if less than 30-40mm (depending on state) is received at each trigger point)
1	15-20	Rs. 300
2	20-30	Rs. 750
3	25-40	Rs. 1,200

Rainfall measured at the block level from AWS (Automatic weather stations)



- We will report intent-to-treat estimates throughout
- Insurance offers randomized by design. Calendar


Rain during 2011 *Kharif* Crop Season in Andhra Pradesh, by Rainfall Station
Insurance Payout Stations in Red (with Rupee Amount)
Centimeters
0
1
2
3
4
5
6
7
8
9
10
300
750
1200
300
Chagallu
Chandragiri
Dattirajeru
Iragavaram
Kurichedu
Mogalthur
Pentapadu
Penukonda
Renigunta
Unguturu
Vuyyuru


Rain per Day in 2011 *Kharif* Crop Season in Uttar Pradesh, by Rainfall Station
Centimeters
0
2
4
6
8
10
12
14
16
18
Baghpat
Barhani
B. B. Nagar
Bilgram
Chahniya
Chakia
Hathras
Janawai
Khair
Madhoganj
Maya Bazar
Nagra
Pura Bazar
Sakaldiha
Sikandrabad

Labor Demand Estimation

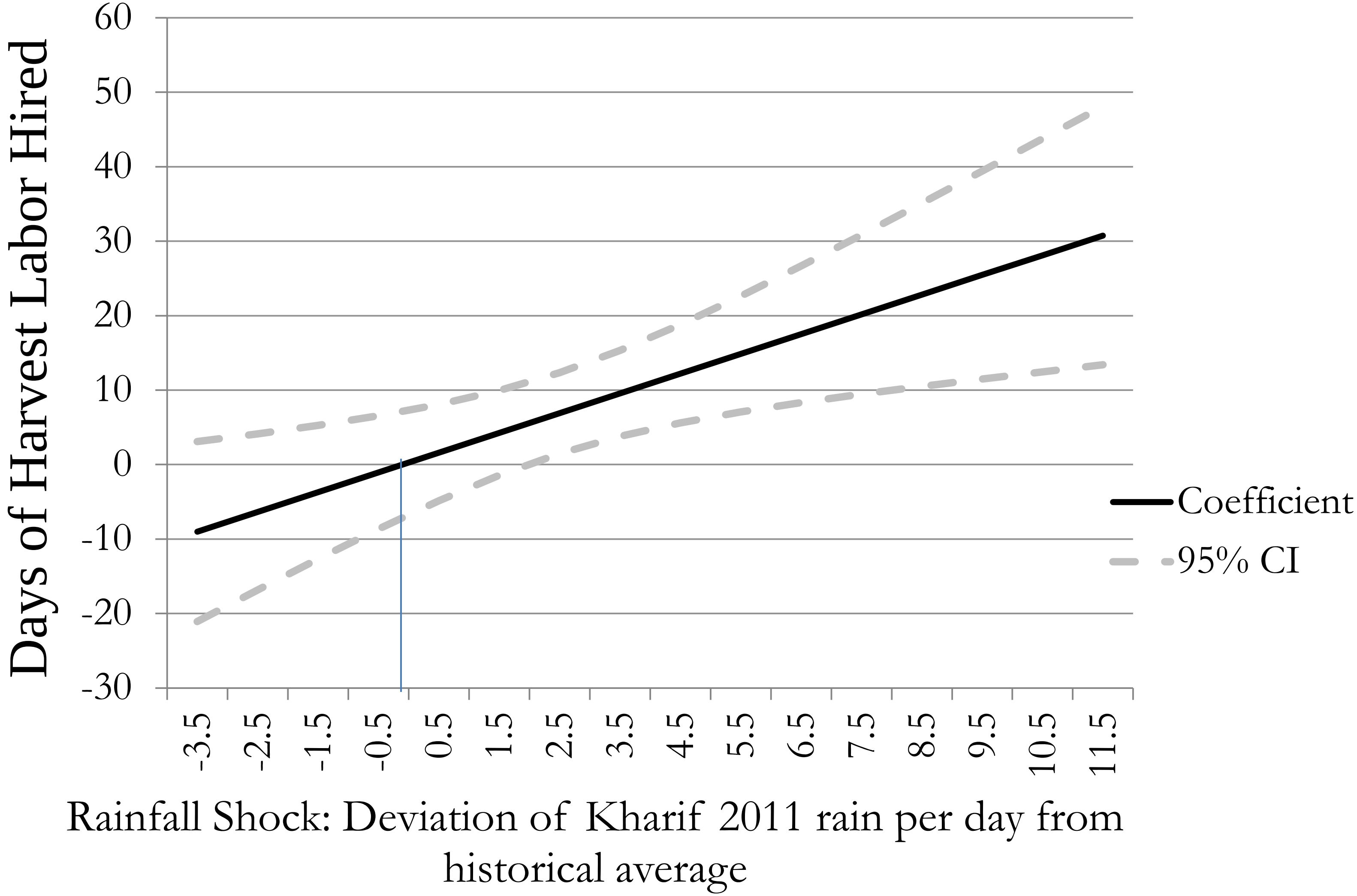
- Prediction: Insured cultivators will use more inputs at the planting stage that are complementary with rainfall than uninsured.
  - They therefore hire more labor for *harvesting* when rainfall is ample.
- $L_{jk}^{D} = \beta_1 I_{jk} + \beta_2 (I_{jk} \cdot R_k) + \beta_3 Acreage + \boldsymbol{K}_k + \varepsilon_{jk}^{1}$
  - *I*: insurance offer (ITT) *R*: 2011 rainfall shock
  - Village fixed effects absorb variation in input prices and historic rainfall

Village and Caste Fixed Effects Estimates: Demand for Kharif Season Labor by Cultivators by Stage of Production (Cultivators with at least 2 acres)

	Days of Harvest Labor		Days of Planting Labor	
Offered Insurance in 2011	2.118 (0.83)	0.270 (0.08)	-3.160 (-1.19)	-0.867 (-0.28)
Offered Insurance x (2011 Rainfall Deviation from Historical Average	1.995 (3.00)	2.651 (2.89)	0.575 (0.83)	-0.239 (-0.27)
Offered Insurance in a Village where Payout Occurred		5.289 (0.86)		-6.564 (-1.09)
Acreage Cultivated	2.053 (2.02)	2.055 (2.01)	2.358 (2.05)	2.356 (2.05)
Observations	734	734	734	734
Predicted Effect of Insurance at Most Negative Rainfall Shock in Sample	-5.009 (-1.34)	-9.200 (-1.49)		
Predicted Effect of Insurance Offer at Most Positive Rainfall Shock in Sample	24.80 (3.27)	30.41 (3.52)		

Caste and Village FE included. t-stats based on Standard errors clustered by village-caste.

Figure 5: Predicted Effect of Insurance Offer on Days of Harvest Labor Hired, by Rainfall Shock



Labor Supply Measures

- $L_{ijk}^{S} = \alpha_1 I_{jk} + \alpha_2 (I_{jk} \cdot R_k) + \boldsymbol{Z}_{ijk}\pi + K_k + \varepsilon_{ijk}^{2}$

- Information for landless households:
  - Participation in the Labor Force
  - Days worked in agriculture for wages
  - Days spent working for wages outside the village (temporary out-migration) – *very low during Kharif*
- *Z*: personal characteristics (age, gender)

Table 6: Village and Caste Fixed Effects Estimates: Labor Supply during Kharif Season by Landless Agricultural Wage Workers Aged 25 – 49

Dependent Variable:	Agricultural Labor Force Participation		Number of Days of Agricultural Work	
	Payout Villages	Non-Payout Villages	Payout Villages	Non-Payout Villages
Offered Insurance	-2.175	-0.194	-338.2	-1.582
	(-4.41)	(-4.08)	(-2.04)	(-0.46)
Offered Insurance x Rainfall Deviation in 2011 from Historical	-1.084	0.0304	-167.3	0.295
	(-4.63)	(2.83)	(-2.03)	(0.21)
Male	0.195	0.114	6.745	8.334
	(5.31)	(4.02)	(1.46)	(3.59)
Observations	515	2,925	264	916
Predicted Effect of Insurance at Median Rainfall in Payout Village	-0.117		-20.33	
	(-1.75)		(-1.23)	
Predicted Effect of Insurance at Median Rain, Non-Payout Village		-0.0421		-0.107
		(-1.26)		(-0.01)

Village and Caste FE included. t-stats based on standard errors clustered by village-caste, in parentheses. Age and age-squared also included as controls.

General Equilibrium Effects on Log Wages (Landless Agricultural Wage Workers Ages 20+)

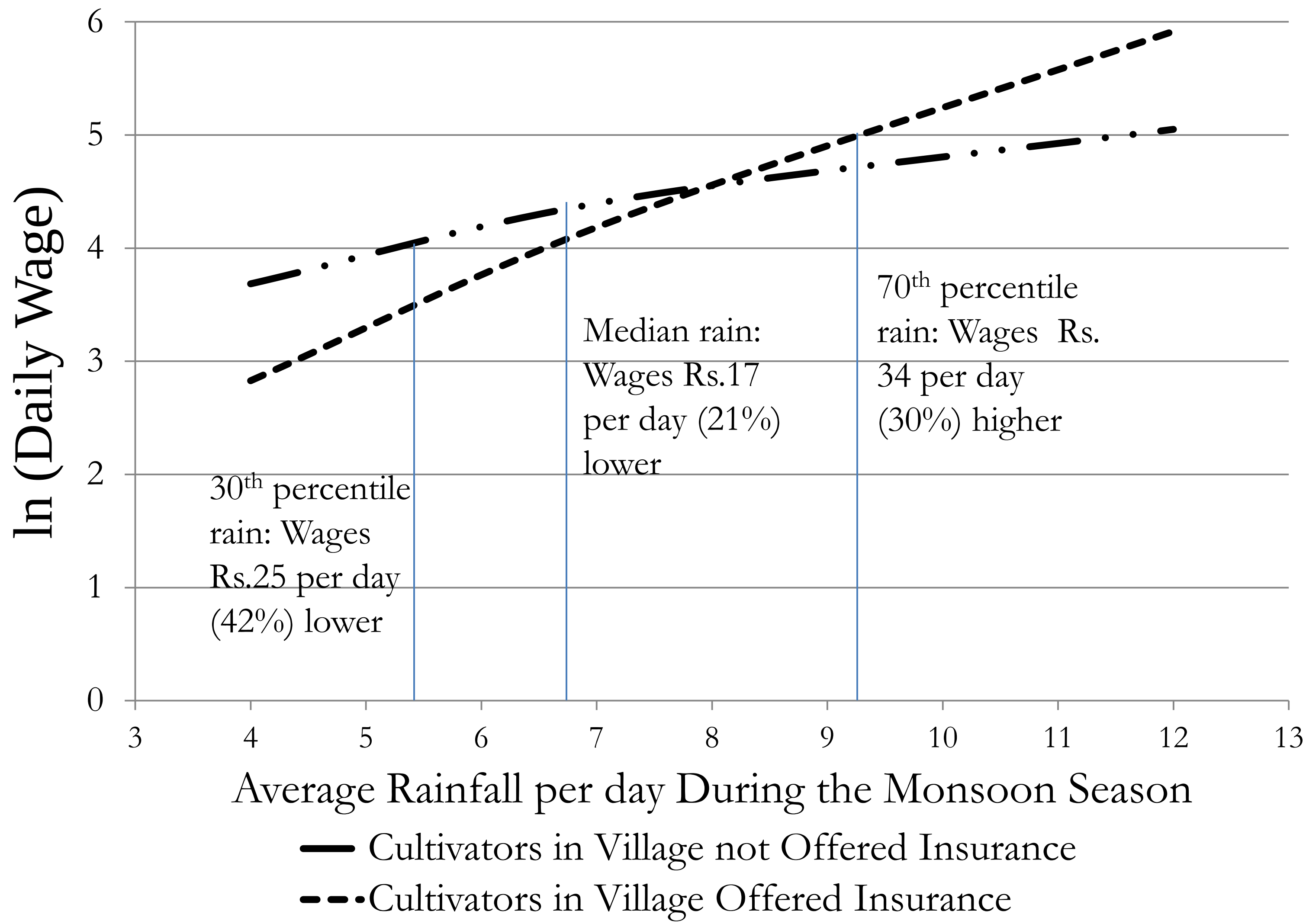
Proportion Cultivators Offered Insurance in 2011	-6.724 (-3.12)
Proportion Cultivators Offered Insurance * Rain per Day in 2011 Kharif Season	0.842 (3.96)
Proportion of Landless Labor Households Offered Insurance in 2011	4.357 (1.76)
Proportion of Landless Labor Households Offered Insurance * Rain per Day in 2011	-0.627 (-3.10)
Proportion of Households Offered Insurance in a Village where Payout Occurred	2.470 (2.66)
Rain per day during 2011 Kharif season	0.804 (7.03)
Rain per day during 2011 Kharif season, squared	-0.0133 (-5.56)
Historical Mean Rainfall	0.0689 (1.18)
Observations	2,693
R-squared	0.337

Robust t-statistics, based on standard errors clustered by village-caste, in parentheses. All specifications include state fixed effects and control for education, age of respondent and a squared term in age, and 11 variables characterizing soil type, depth and drainage characteristics. All specifications also include 6 variables controlling for the proportion of village that are agricultural laborers or cultivators, and their interactions with rain per day, and proportion village laborers or cultivators that are eligible to receive insurance marketing.

- Cultivator Insurance increases wage volatility
- Laborer insurance reduces wage volatility
- Payouts increase wages
- t-stats in parentheses

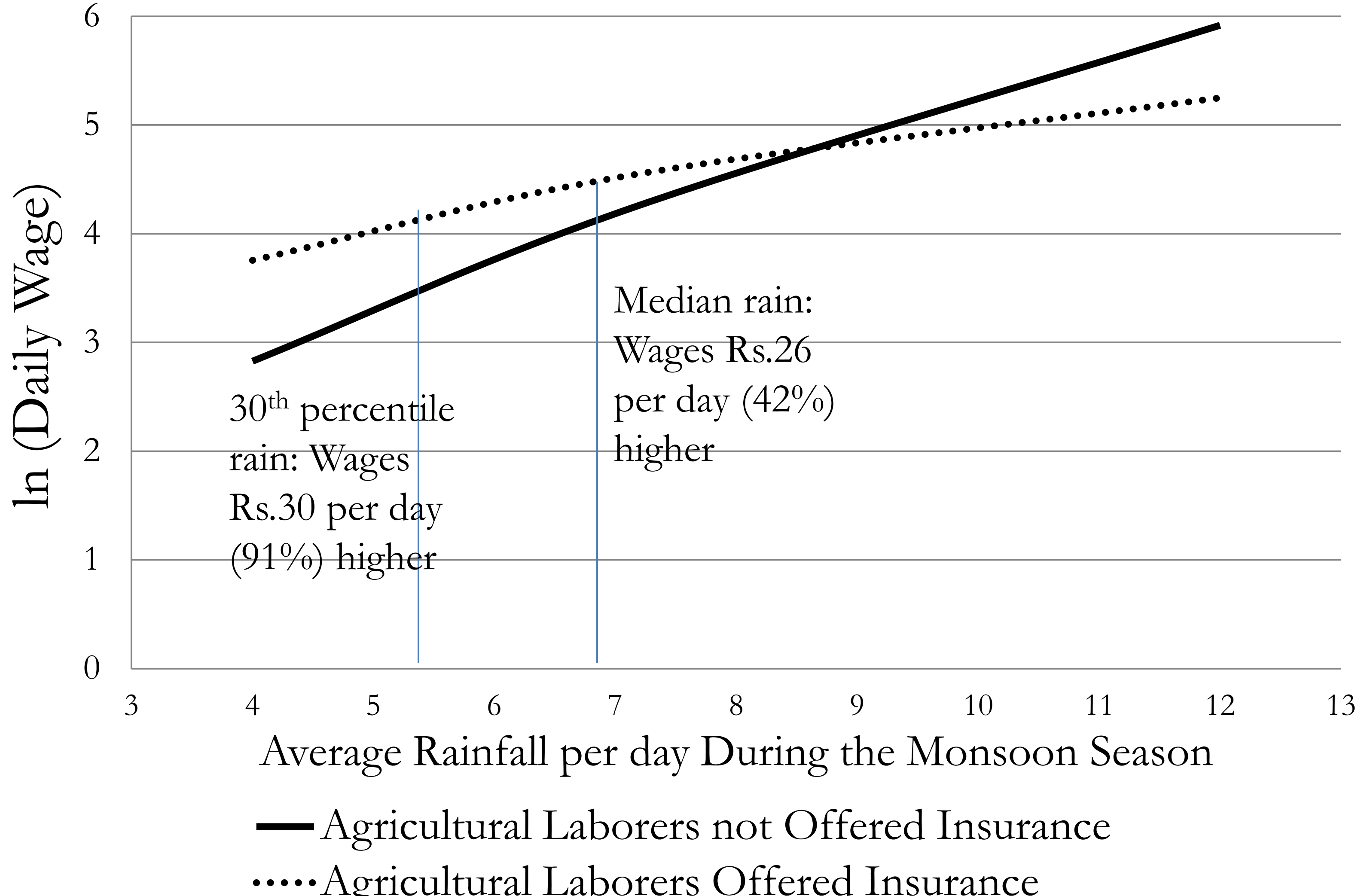
(p-values <0.001)

Effect of Marketing Rainfall Insurance to **Cultivators** on the Equilibrium Wage Rate



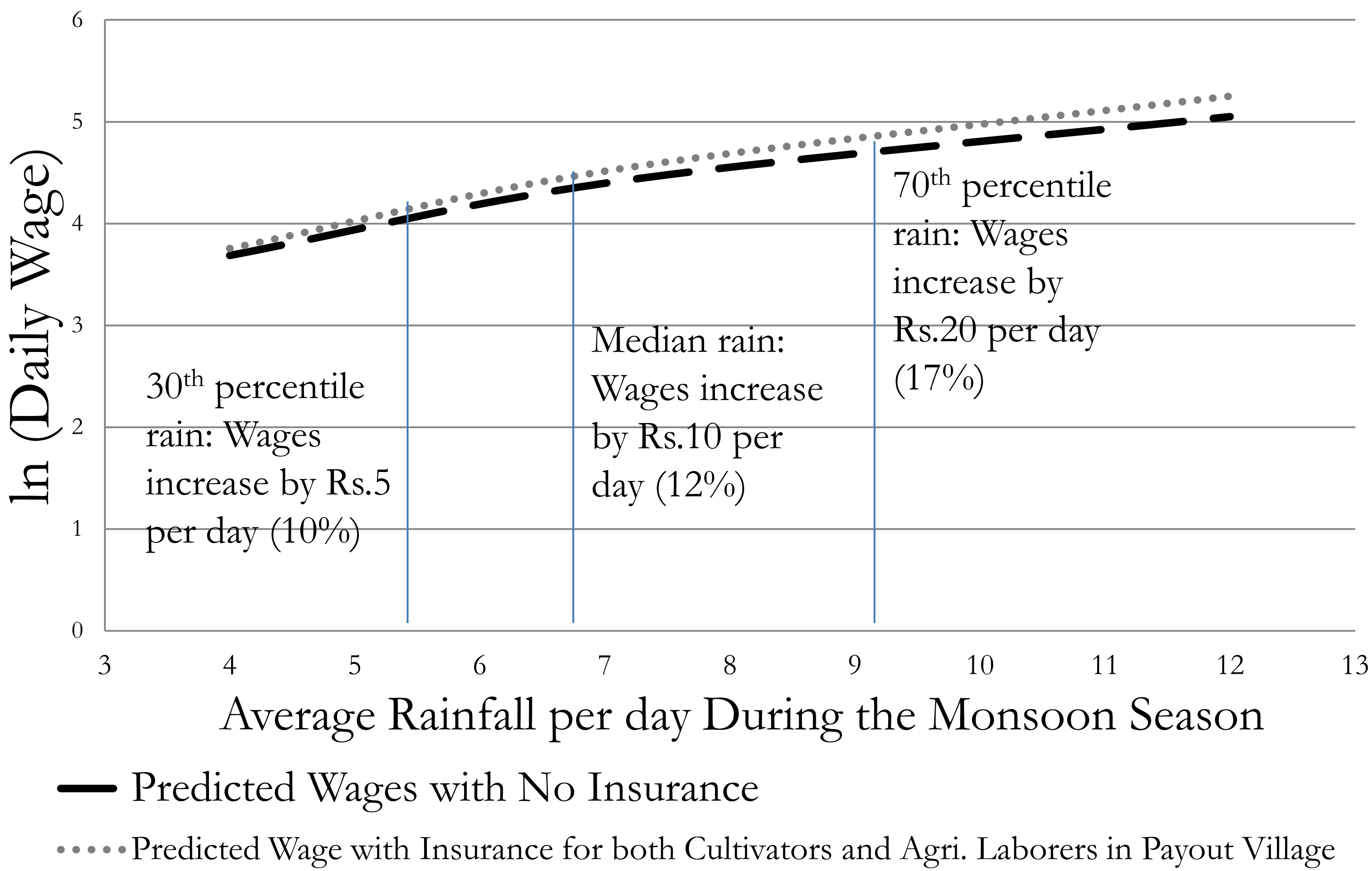
The wage rate is predicted based on the wage equation estimated in the first column of Table 4. Assumes an "average" village in terms of banks, roads, bus stops and fractions of cultivators and agricultural laborers in the populations, and that laborers do not receive insurance marketing. Graph is plotted for 2 standard deviations of rainfall per day around the mean.

Effect of Marketing Rainfall Insurance to **Agricultural Laborers** on the Equilibrium Wage Rate in **Payout** Village



The wage rate is predicted based on the wage equation estimated in the first column of Table 4. Assumes an "average" village in terms of banks, roads, bus stops and fractions of cultivators and agricultural laborers in the populations, and that cultivators receive insurance marketing. Graph is plotted for 2 standard deviations of rainfall per day around the mean.

Effect of Marketing Rainfall Insurance to **both Laborers and Cultivators** on the Equilibrium Wage Rate



The wage rate is predicted based on the wage equation estimated in the first column of Table 4. Assumes an "average" village in terms of banks, roads, bus stops and fractions of cultivators and agricultural laborers in the populations. Graph is plotted for 2 standard deviations of rainfall per day around the mean. The "insurance" line considers a case where the sample-maximum fractions of cultivators and agricultural laborers are offered insurance.

C. What about farm scale?

Relevance to land reform: what size of farms is optimal?

Caveat: may depend on how well labor, land markets work

What is the evidence: old literature showing *small* farms more efficient

based on India, before mechanization

Across countries, evidence is strong for large farms being more productive.

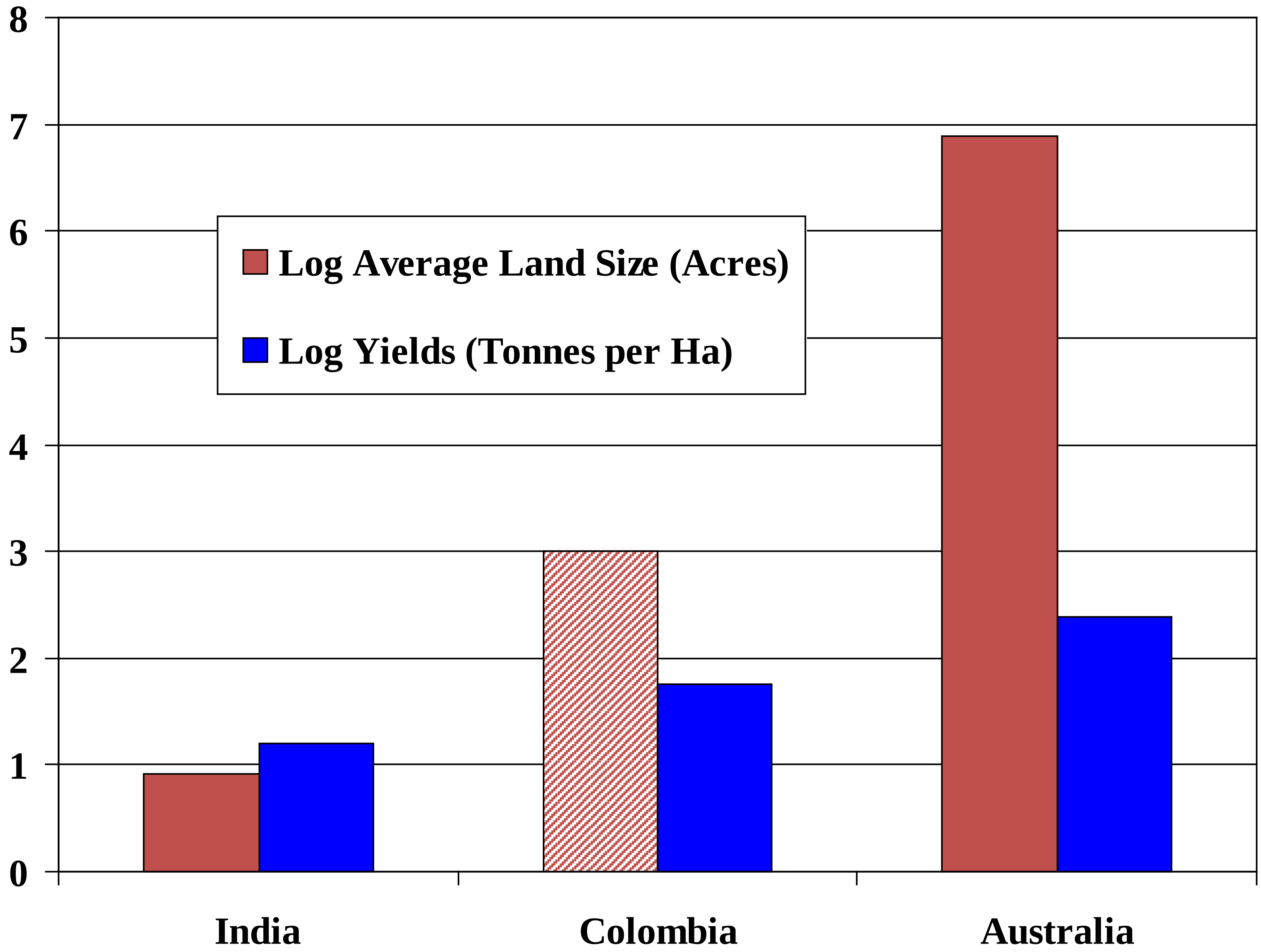
Example: Rice

Key may be possibilities of the scale economies of mechanization.

Example: Rice

But we need rigorous evidence.

Figure A3. Average Rice Farm Size and Rice Yields Across Three Countries (Logs)



Rice Harvesting Technologies Around the World

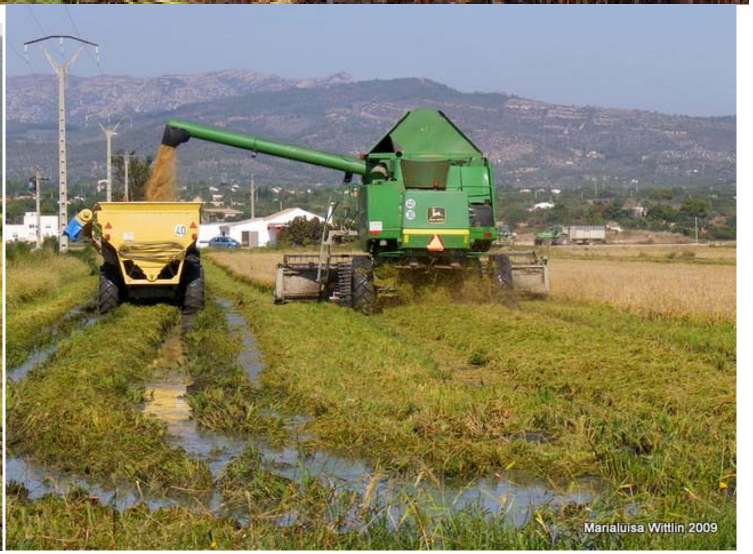


Figure A3. Cumulative Distribution of Operational Landholdings (Acres) in the US

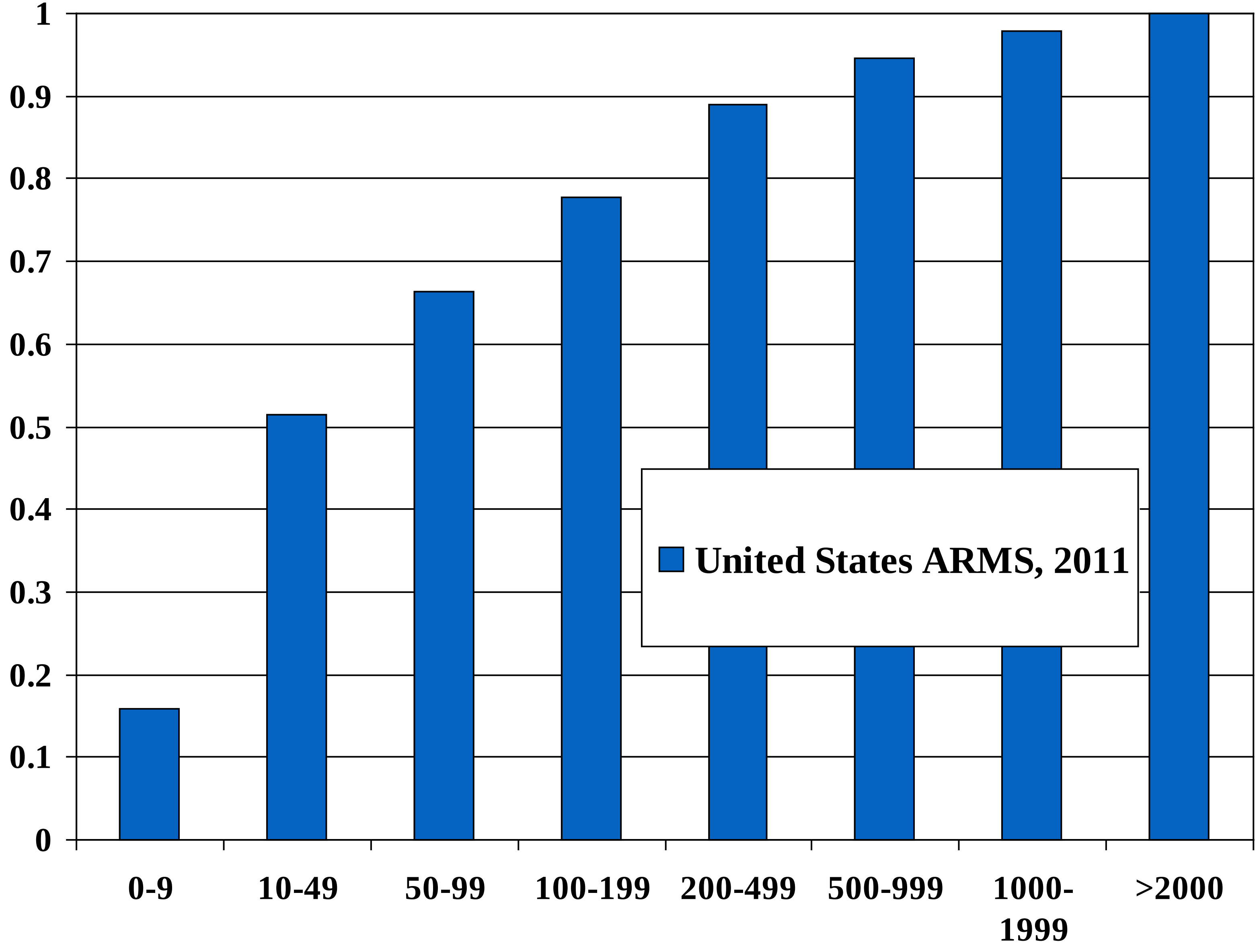
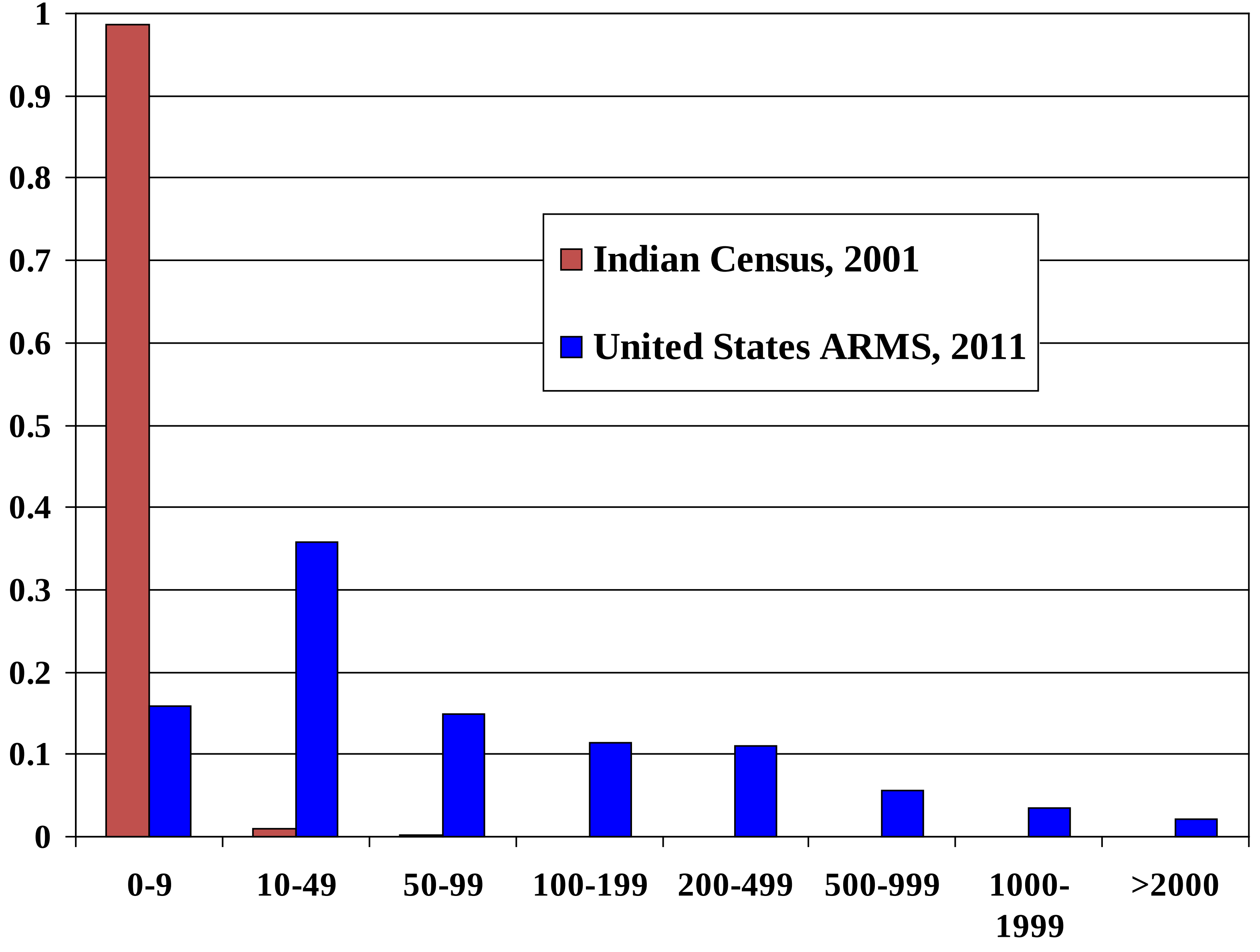


Figure A3. Distribution of Operational Landholdings (Acres): India and the United States



Research:

A. Panel and plot-specific data from India in recent period.

B. Exploit empirically

1. Differences in plot sizes for the same farmer

   Which are more productive?

   Differences cannot be due to financial constraints or farmer ability.

   Need to worry about plot quality.

2. Division of farm land due to the death of the household head and inheritance.

   Same original household, working smaller farm scale.

What are possible key elements of scale economies?

A. Economies of scale in machinery.

8-row harvester more efficient than 4-row harvester.

Cannot use 8-row harvester on small plots.

B. Land is good collateral: reduces loan costs.

Key element of scale *dis*-economies:

A. Labor costs: use of hired labor increases supervision costs

We do find that hired labor is twice as costly as family labor when you take into account supervision

But, machinery reduces the use of labor, reduces labor costs

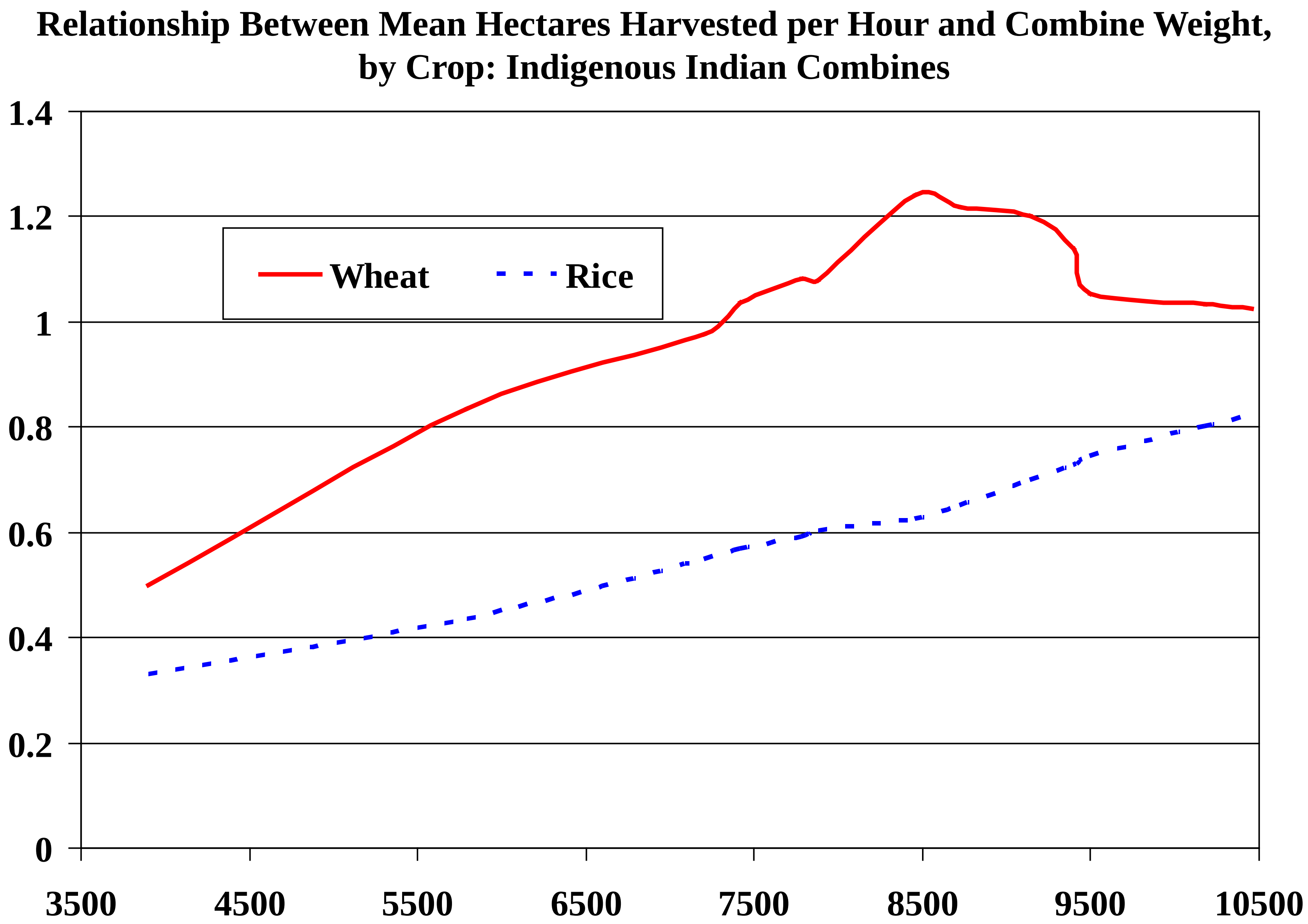
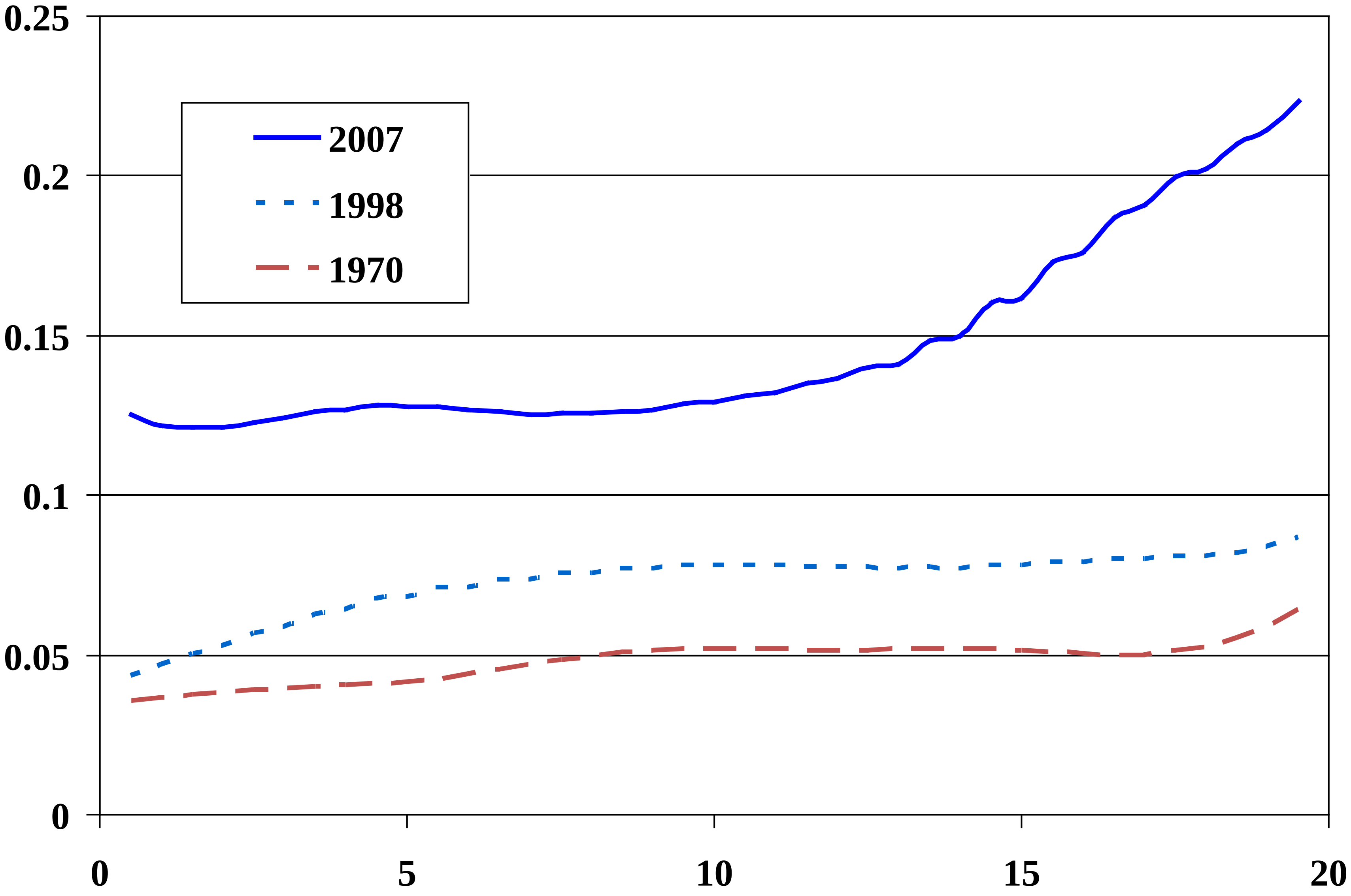

Relationship Between Mean Hectares Harvested per Hour and Combine Weight, by Crop: Indigenous Indian Combines
1.4
1.2
1
0.8
0.6
0.4
0.2
0
3500
4500
5500
6500
7500
8500
9500
10500
Wheat
Rice

Figure 1. Proportion of Farms with Mechanized Farming Equipment, by Owned Landholdings and Survey Year



Total Mandays of Labor Used per Acre, Adjusted for Gender and Age, by Owned Landholding Size

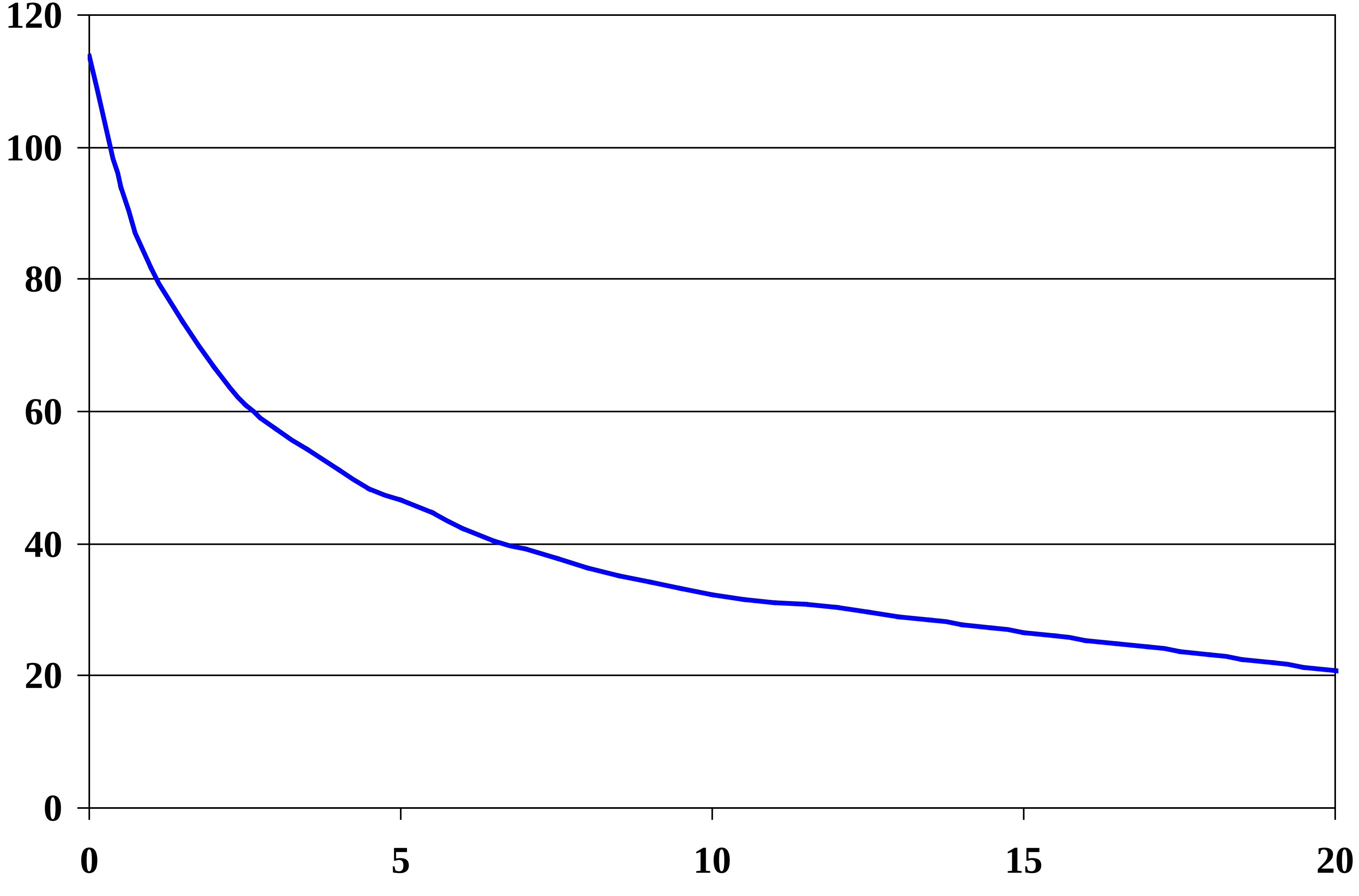
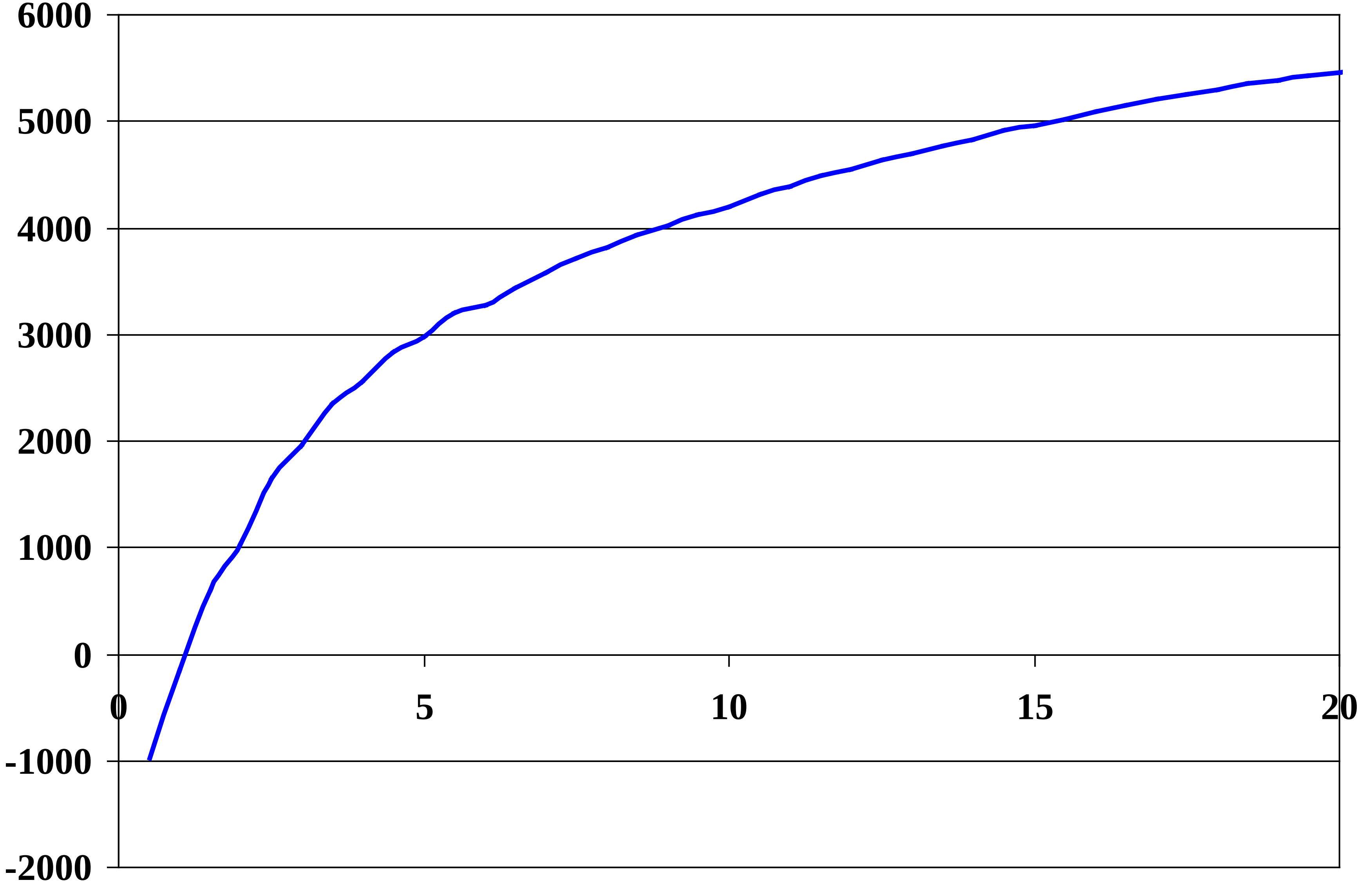


Figure 3. Per-Acre Profitability, by Owned Landholding Size (2007-8)



These relationship are descriptive; we want to know the causal effect of increasing land size on per-acre profitability

We use the panel data 1999-2007-8 to estimate:

(25) $$\pi_{jt}^* = \mathrm{d}_{0t} + \mathrm{d}_A A_{jt} + \mathrm{d}_k k_{jt} + \mu_j + \varepsilon_{ijt},$$

where t = survey year k=value of all farm machinery
μ_j=unobservable household fixed effect ε_{ijt}=an iid error

Prior research has estimated (25) using fixed effects, differencing (25)

(26) $$\Delta\pi_{jt}^* = \Delta \mathrm{d}_0 + \mathrm{d}_A \Delta A_j + \mathrm{d}_k \Delta k_j + \Delta\varepsilon_{ijt},$$

where Δ is the intertemporal difference operator

This eliminates unobserved permanent farm attributes like land quality, farmer capability

But, $\mathrm{cov}(\Delta\varepsilon_{ijt}, \Delta A_j) < 0$ FE technique introduces a negative bias, where credit is constrained even if the ε_{ijt} are iid (we show)

Again, we employ instrumental variables to predict the changes in assets and landholdings due to division and inheritance between 1999 and 2007-8

We use information on:

A. Inheritances between 1999 and 2007-8: land, mechanized inputs

B. Inheritances prior to 1999: land, mechanized inputs

C. Father's age, residence in 1999, inequality of brother's education in 1999, number of brothers in 1999

First-stage equations

Estimates of landholdings on profits per-acre, by estimation procedure

Local IV estimates of positive marginal farm size effects on profits by farm size: large for small farms and decline to 20 acres

Local IV estimates of the returns to capital by farm size: decline and vanish at 10 acres

Table A2
First-Stage Estimates for Profit Function (1999-2007/8 Panel)

	ΔLand	ΔFraction Irrigated	ΔFarm Equipment ($x10^{-3}$)
Inherited land between 1999 and 2007-8	.195 (4.52)	-.00032 (0.10)	1.00 (1.70)
Inherited fraction of irrigated land by 1999	.735 (2.61)	-.446 (2.35)	18.5 (4.80)
Head's father not co-resident in 1999	.688 (1.20)	.0365 (0.82)	6.19 (0.79)
Head's father's age in 1999	-.00464 (0.45)	-.00024 (0.30)	-.127 (0.90)
Number of head's brothers in 1999	.102 (0.32)	.00264 (0.11)	4.27 (0.98)
Head's brothers co-resident in 1999	-.557 (3.67)	-.00203 (0.17)	-1.64 (0.79)
Standard deviation of brothers' schooling, 1999	-.060 (1.05)	-.00107 (0.24)	2.05 (2.62)
Inherited value of mech. assets by 1999 ($x10^{-3}$)	.00385 (0.70)	.00062 (1.44)	.0649 (0.86)
Inherited value of non-mechanical assets by 1999 ($x10^{-3}$)	-.0882 (1.99)	-.00016 (0.05)	3.55 (5.87)
Inherited assets between 1999 and 2007-8 ($x10^{-3}$)	.540 (0.54)	.0376 (0.48)	-10.7 (0.78)
N	1,374	1,374	1,374
Cragg-Donald Wald statistic, underidentification, $\chi^2(8)$ [p] 39.42 [.00]			

Asymptotic t-ratios in parentheses.

Table 2. Panel Data Estimates (1999-2008):
Effects of Landholdings and Farm Equipment on Profits per Acre (Supervision Costs-adjusted), by Estimation Procedure

Est. procedure:	Village Fixed-Effects[a]			Farmer Fixed-Effects			Farmer Fixed-Effects IV[b]		
Owned landholdings	44.7 (4.47)	46.6 (4.62)	41.7 (4.02)	42.3 (1.53)	54.5 (1.91)	54.6 (1.91)	577.8 (3.15)	653.1 (2.79)	712.8 (2.63)
Fraction irrigated	-	957.8 (3.64)	936.2 (3.55)	-	1226 (3.11)	1222.9 (3.10)	-	4255 (2.52)	4404.2 (2.25)
Value of farm equipment	-	-	.00290 (2.05)	-	-	.00007 (0.16)	-	-	.0189 (1.39)
N	3,967	3,967	3,967	3,967	3,967	3,967	3,524	3,524	3,524
Farmers	2,221	2,221	2,221	2,221	2,221	1,749	1,745	1,654	1,654
Kleinberger-Paap underidentification test statistic χ^2, p-value							11.8, .0372	19.5, .0122	15.1, .0575
Hansen J overidentification test statistic χ^2, p-value							0.63, .960	6.76, .455	10.3, .174

Absolute value of asymptotic t-ratios in parentheses. [a]Specification includes year=2008 dummy; clustered t-ratios at the household level.

Figure 4. Locally-weighted FE-IV Estimates of the *Effects* of Land Owned on Profits per Acre (and one sd Confidence Bounds), by Landholding Size

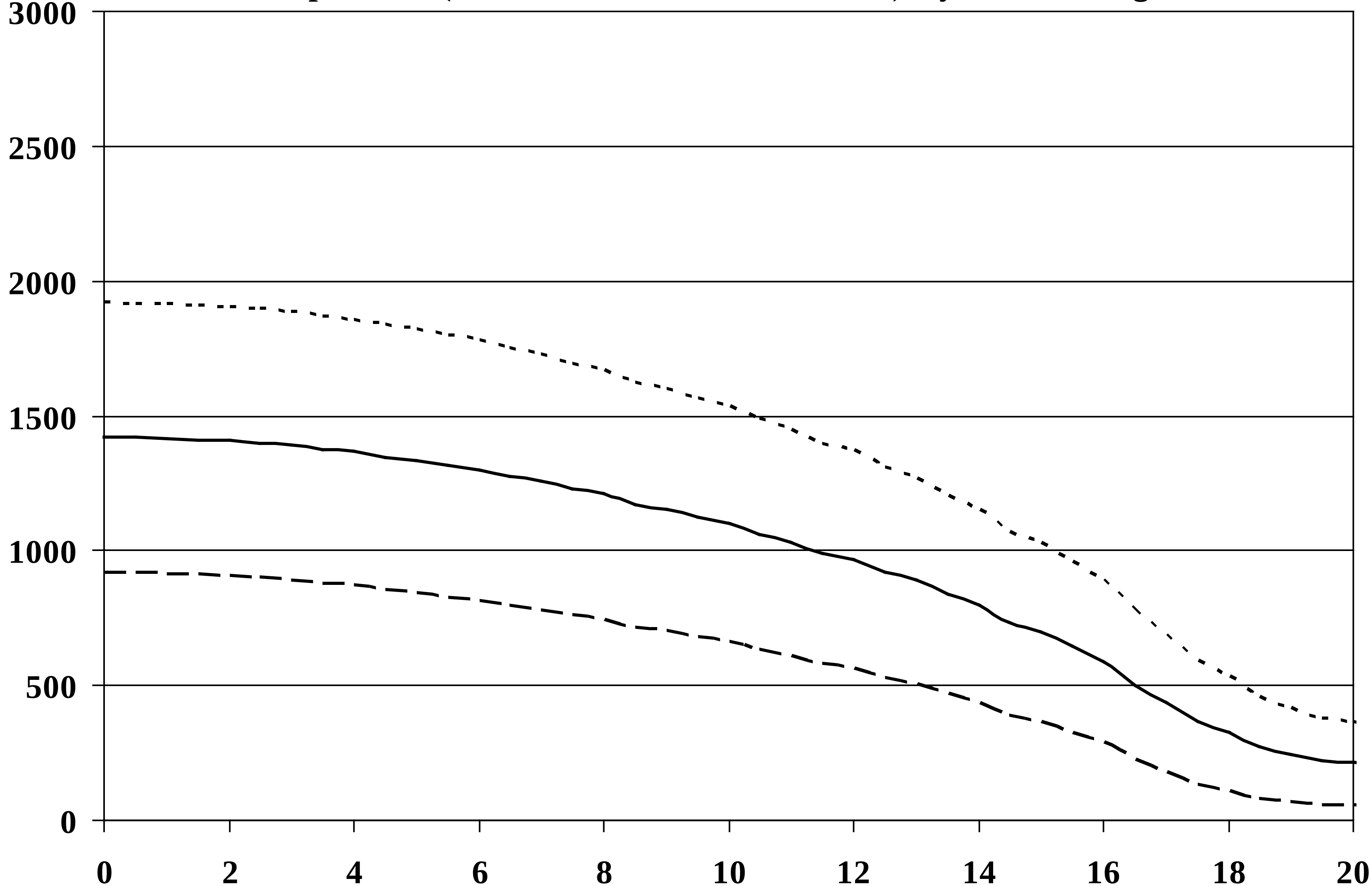
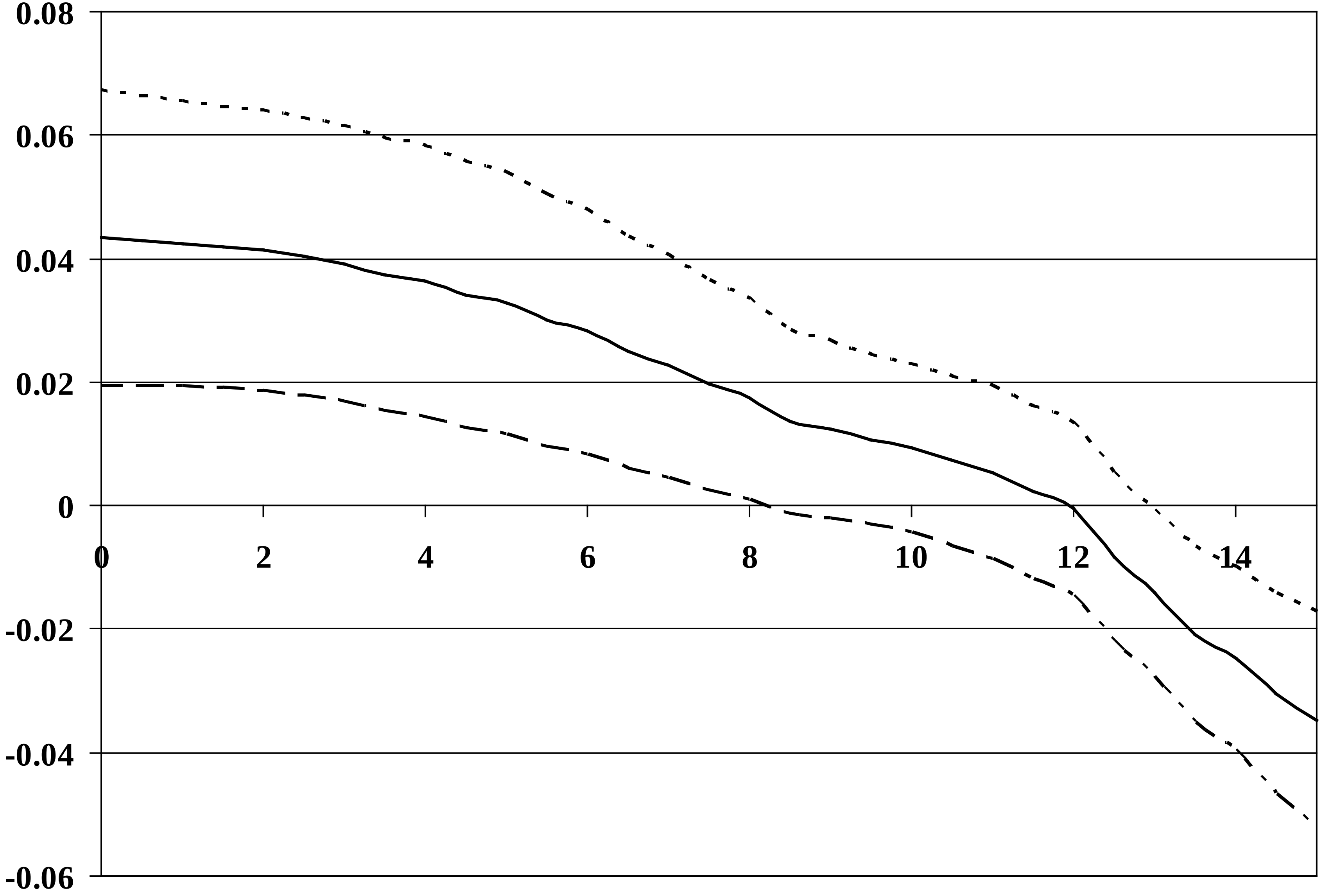


Figure A5. Locally-weighted FE-IV Estimates of the Returns to Capital Equipment Value (and one sd Confidence Bounds), by Landholding Size



Owned land size effects on and equipment purchase and rental

Do larger farms purchase or rent more machinery, given increased scale and lower credit costs?

We estimate using FE and IV

(27) $$K_{kjt} = e_{0t} + e_A A_{jt} + e_k k_{jt} + e_B B_{jt} + \mu_j + \eta_{ijt},$$

where K=equipment purchase in a 3-year period B=bank proximity.

We expect that $e_A>0$, $e_k<0$, and $e_B>0$

We use retrospective information from the 2007-8 survey on splits, inheritances and investments between 1999 and 2007-8.

25% of households in 2007-8 experienced an increase in owned landholdings (less than 2% sold or purchased)

79% through inheritance due to household division

Note: if not the head in 1999, then owned landholdings = 0

Table 3. Retrospective Panel Data Estimates (2008):
Effects of Landholdings and Farm Equipment on Investment in and Rental of Farm Equipment, by Estimation Procedure

Dependent variable	Equipment Investment		Equipment Hire Expenditure	
Estimation procedure	FE-Farmer[a]	FE-Farmer IV[b]	FE-Farmer	FE-Farmer IV[b]
Owned landholdings	23.4 (0.08)	916.9 (2.13)	125.5 (1.94)	185.6 (2.55)
Value of owned farm equipment	-.0874 (1.61)	-.740 (4.49)	-.0187 (4.36)	-.0326 (1.67)
Bank within 10 Km	3267 (3.05)	4187.9 (2.68)	-328.1 (1.67)	-328.6 (1.66)
Number of farmers	2,570	2,570	1,822	1,822
Kleinberger-Paap underidentification test statistic χ^2(df), p-value		(6) 17.2, .0085		(6) 12.8, .0464
Hansen J overidentification test statistic χ^2(df), p-value		(5) 4.64, .461		(5) 2.08, .838

Absolute value of asymptotic t-ratios in parentheses. [a]Specification includes year=2008 dummy; clustered t-ratios at the village level.

Identifying pure scale effects

The estimated landholding effects on profits and equipment reflect the net influence of:

A. Changes in unit labor costs (agency)

B. Changes in interest costs

C. Scale economies associated with the use of higher-capacity, labor-saving capital equipment

We use variation in profits and inputs <u>across plots for a given farmer within a season</u> to identify pure scale effects (C.)

Within-farmer/season plot size effects hold constant:

unit labor costs, access to credit, owned farm machinery, and farmer capability

The 2007-8 survey provides all inputs and outputs (by stage) at the plot level

What is a “plot”? contiguous area of land considered by the farmer to be his basic unit of farming

Is plot size exogenous? Yes, mainly

The smallest land unit is a “parcel”

Three-fourths of plots are a single parcel; the rest are sets of contiguous parcels

96% of parcels are inherited or, in a few cases, acquired from a parent

Plot size is thus determined by the location and configuration of inherited family-owned parcels

Are plots of similar quality? No

We have information by plot on depth, salinity, percolation, drainage, color (red, black, grey, yellow, brown, off-white), type (gravel, sandy, loam, clay, and hard clay) and distance from the farmer homestead.

We are thus able to control for plot characteristics (not much difference)

The plot-specific equation we estimate is

(28) $$\pi_{ijt}^* = b_{0j} + b_A A_{ijt} + b_I I_{ijt} + \boldsymbol{X_{ij}}\mathbf{a}_x + u_{ijt},$$

where

π_{ijt}^*=profits per acre on plot i for farm j in season t

b_{0j}=farmer/season fixed effect

A_{ijt}=plot area (acres)

I_{ijt}=whether the plot is irrigated

$\boldsymbol{X}_{ij}$=vector of soil and location plot characteristics

u_{ijt} = an iid error

We want to test if $b_A > 0$

Note: b_A biased downward if there is measurement error in A_{ijt}

Do the pure scale effects reflect mechanization?

Estimate the effect of plot size on the probability of using a tractor on that plot

Estimate the effect of plot size on profits in areas with the presence of a formal tractor rental market (36.4% of survey villages in 2006)

Findings:

Tractor use more prevalent on larger plots

Plot size effects are more positive where there are formal tractor rental markets

Per-unit labor use lower on larger plots, especially where there are formal tractor rental markets

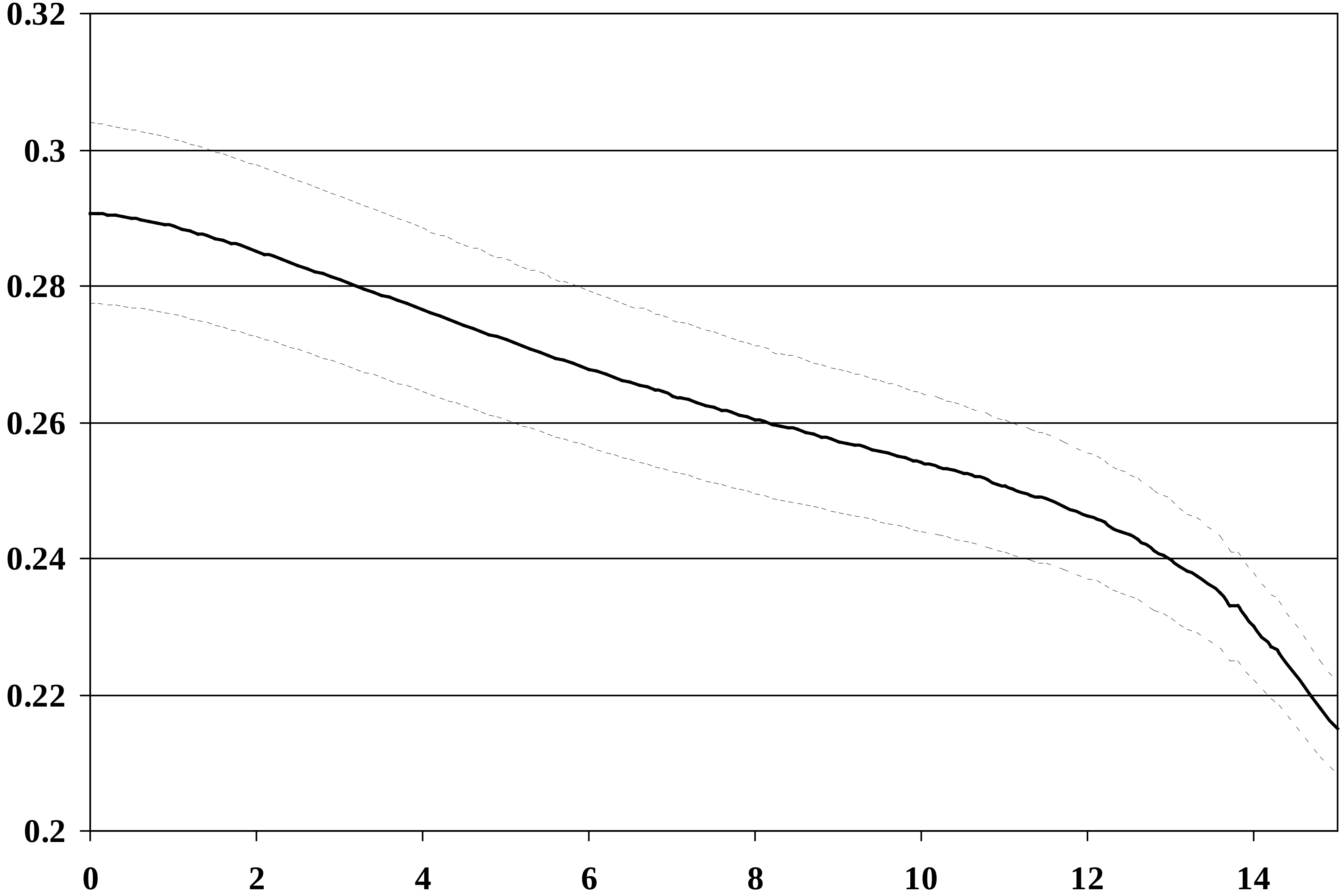
True also for rice farmers - not the result of differences in crop choice by plot size

Table 4. Within-Farmer/Season Plot-Level Estimates (2007-8):
Effects of Plot Size on Plot-Specific Profits and Labor Costs and Use of Tractor Services

Variable	Profits per Acre		Total Labor Costs per Acre		Any Mechanized Services Used[b]		Total Days Mech. Services		Mech. Rental Price per Day	
Plot area	536.3 (4.55)	534.9 (4.54)	-610.5 (5.49)	-615.2 (5.50)	.303 (2.01)	.317 (1.93)	.185 (8.47)	.185 (8.64)	256.6 (7.60)	254.7 (7.55)
Whether plot irrigated	1564.6 (2.93)	1515 (2.84)	-105.9 (0.17)	-151.9 (0.27)	.962 (2.29)	1.01 (2.25)	.100 (2.11)	.0718 (1.44)	78.6 (1.14)	88.6 (1.34)
Include soil characteristics?[a]	N	Y	N	Y	N	Y	N	Y	N	Y
Number of plot observations	16544	16544	16544	16544	16544	16544	11675	11675	9665	9665
Number of farmers	7,845	7,845	7,845	7,845	7,845	7,845	5,519	5,519	4,758	4,758

Absolute value of asymptotic t-ratios in parentheses clustered at the village level. [a]Soil characteristics include depth, salinity, percolation and drainage; five soil colors (red, black, grey, yellow, brown, off-white); five soil types (gravel, sandy, loam, clay, and hard clay). [b]ML conditional logit estimates.

Figure 7. Local Within-Farmer/Season Estimates: Effect of Plot Size on Per-Acre Days of Mechanized Equipment Services Used and Confidence Bands



Conclusion

1. Importation of new seeds can substantially improve farm productivity and wages and induces human capital investment, but is not transformational.

2. Improvements in financial markets (insurance) must be made available to *all* agents but may have modest effects in reducing under-investment.

3. There appear to be significant unrealized scale economies to agriculture.

Key point: A single reform is usually not adequate:

Improving technology when there are barriers to land expansion

Rectifying financial markets without attention to the barriers to investment opportunities and land markets

Redistributing land without attention to scale economies, access to technologies and financial resources, and land markets (property rights)

Each will not have promised impacts without *holistic* approach to agricultural reform.