Are Indian Farms Too Small? Mechanization, Agency Costs, and Farm Efficiency

Andrew Foster and Mark Rosenzweig

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Landsize

- Are small Indian farms efficient:
  - Large empirical literature using data from 1970s/1980s
  - Higher labor use and negative yield area relationship
  - But this ignores costs of inputs

- When costs are priced out at market wages generally see higher profitability for larger farms. (Carter, 1984; Lamb, 2003)
  - But it is not clear that either approach is right.
  - Clearly given activity of labor market the shadow value of family work is not zero
  - But if shadow value is the wage then it is unclear why labor-land ratio is higher on small farms.

- One hypothesistied to differences in supervisory cost. Feder (1985); Eswaran and Kotwal (1986)
Figure A2. Cumulative Distribution of Owned Landholdings (Acres), by Data Source

- Indian Census, 2001
- NCAER Listing Data 2006

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Labor per acre by acreage

Figure A3. Total Mandays of Labor Used per Acre, Adjusted for Gender and Age, by Owned Landholding Size
Emergence of machinery by farm size

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

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Rice Harvesters of Different Capacity

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Model

- Delivers a formula for costing out family labor and
- Shows that cost of labor varies by regime and thus must be computed by stage of production.
- Links scale economies to mechanization through machine capacity and the scale-specific cost of combined machine/human effective effort.
- Scale economies are tied to contiguous land.
- Links scale and mechanization to credit market imperfections.
- Provides a framework for constructing a rental reservation price.
Key equations

- \( g_{ei} e_{il} = w_i^r = \frac{1+s_f}{1-h_i(s_f-s_h)} w_i \)

- \( h_i = \begin{cases} 
0 & \text{family working off farm} \\
1 & \text{hiring workers in} \\
[0..1] & \text{neither hiring in or out} 
\end{cases} \)

- \( \nu = \pi(a) + a \frac{d\pi(a)}{da} \bigg|_{h_i} \)

- \( \nu = \nu + \sum_i (w_i^r - w_i)(l_f + a \frac{dl_f}{da}) \)
Main data sets

- 1999 REDS both carried out by the National Council of Applied Economic Research (NCAER).
- 17 of the major states of India, with Assam and Jammu and Kashmir the only major states excluded.
- Original 1968-69 representative with over sampling of better off households.
Sample sizes

- Listing 120,000 households,
- 2007-8 household survey includes 4,961 crop cultivators who own land.
- Panel households 2,848 panel households (1999 and 2007-8)
- Data on 10,947 plots most for multiple seasons,
Plots

- Plots include multiple parcels of land
- With about two-thirds of the plots observed at least twice (two seasons or more).
- Plots compose of contiguous parcels that operate as a cultivating unit only 4
- Plots median distance is 400 meters
- Includes soil characteristics and distance to home
Profits empirical output priced at farm gate, labor and market wage by male/female/child. Includes family labor cost.

Inputs divided up by stage of productions

Land and equipment that is sold, purchased, destroyed, transferred or inherited. Less than 3 percent of farmers bought or sold land outside family

Land is augmented largely through household division/death of father.
Land Transactions

- Only 4.6 percent of cultivated plots, over the three seasons, are rented (4.9 percent of area).
- 72 percent from parents and siblings (except in West Bengal where 94 percent from other or landlord)
- Only 5 percent of panel farmers sold land over 1999-2007 panel
- Of these 95 percent of sales to family members
Identification

- Use overtime inheritance and family division to see effects of land size changes on scale
- Use across-plot variation for same farmer to remove scale effects from credit and labor cost
- Use multiple-plots over time to distinguish credit shock effects from nutrient depletion effects
## Supervision

Table 1. Panel Data Estimates (1999-2008): Effects of the Use of Hired and Family Labor on Supervision Time (Adjusted Mandays), by Estimation Procedure

<table>
<thead>
<tr>
<th>Estimation procedure:</th>
<th>OLS</th>
<th>Farmer Fixed-Effects</th>
<th>Farmer Fixed-Effects-IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hired labor mandays, adjusted for sex/age</td>
<td>.0906 (2.62)</td>
<td>.0977 (3.39)</td>
<td>.573 (2.81)</td>
</tr>
<tr>
<td>Family labor mandays, adjusted for sex/age</td>
<td>.170 (2.96)</td>
<td>.0844 (2.41)</td>
<td>.138 (2.10)</td>
</tr>
<tr>
<td>Test statistic, H₀: supervision costs= χ²(1), p-value</td>
<td>0.89 (.345)</td>
<td>0.02 (.812)</td>
<td>3.76 (.0525)</td>
</tr>
<tr>
<td>Number of observations</td>
<td>3,280</td>
<td>3,280</td>
<td>3,280</td>
</tr>
<tr>
<td>Number of farmers</td>
<td>1,640</td>
<td>1,640</td>
<td>1,640</td>
</tr>
</tbody>
</table>
Labor utilization regimes

Figure 2. Fraction of Agricultural Labor Employed in Three Labor Regimes, by Landholding Size

- Regime 1: No hiring, family sells labor
- Regime 2: Hiring labor
- Regime 3: Anarchy, no hiring or selling

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Adjusted Profits

Figure 3. Measures of Per-Acre Productivity, by Owned Landholding Size (2007-8)

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Marginal Effects of Land on Profits

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

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Cross-plot evidence of pure-scale effects

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

<table>
<thead>
<tr>
<th></th>
<th>Profits per Acre</th>
<th>Total Labor Costs per Acre</th>
<th>Any Tractor Services Used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plot area</td>
<td>536.3</td>
<td>-610.5</td>
<td>.303</td>
</tr>
<tr>
<td></td>
<td>(4.55)</td>
<td>(5.49)</td>
<td>(2.01)</td>
</tr>
<tr>
<td>Whether plot irrigated</td>
<td>1564</td>
<td>-105.9</td>
<td>.962</td>
</tr>
<tr>
<td></td>
<td>(2.93)</td>
<td>(0.17)</td>
<td>(2.29)</td>
</tr>
<tr>
<td>Formal equipment rental market</td>
<td>713.5</td>
<td>-770.4</td>
<td>.0662</td>
</tr>
<tr>
<td>in village*area</td>
<td>(1.73)</td>
<td>(2.09)</td>
<td>(0.14)</td>
</tr>
<tr>
<td>Include soil characteristics?</td>
<td>N</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Number of plot observations</td>
<td>16,54</td>
<td>16,54</td>
<td>16,54</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Number of farmers</td>
<td>7,845</td>
<td>7,845</td>
<td>7,845</td>
</tr>
</tbody>
</table>

Absolute value of asymptotic t-ratios in parentheses clustered at the village level. *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). bML conditional logit estimates.

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Cross-plot evidence of credit effects

Table 5. Within-Plot Estimates Across Three Seasons (2007-8):
Effects of Previous-Period Farm-Level Profit Shocks on Plot-Level Current Profits per Acre, by Owned Landholding Size

<table>
<thead>
<tr>
<th>Farm size:</th>
<th>Owned Landholdings&lt;4</th>
<th>Owned Landholdings&gt;=4, &lt;10</th>
<th>Owned Landholdings&gt;=10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm profits per acre, all other plots, previous season</td>
<td>0.0848 (2.10)</td>
<td>0.112 (1.45)</td>
<td>-0.0426 (0.62)</td>
</tr>
<tr>
<td>Farm profits per acre, this plot, previous season</td>
<td>-0.479 (8.25)</td>
<td>-0.549 (5.01)</td>
<td>-0.540 (3.01)</td>
</tr>
<tr>
<td>Fertilizer use, this plot, previous season (value per acre)</td>
<td>1.14 (2.15)</td>
<td>0.777 (2.11)</td>
<td>0.363 (2.72)</td>
</tr>
<tr>
<td>Number of plot observations</td>
<td>5,802</td>
<td>3,060</td>
<td>1,964</td>
</tr>
<tr>
<td>Number of farmers</td>
<td>3,595</td>
<td>1,967</td>
<td>1,234</td>
</tr>
</tbody>
</table>

Absolute value of asymptotic t-ratios in parentheses clustered at the farm level. Specifications include season*village dummy variables.
Willingness to pay

Figure 5. Estimated Reservation Rental Rate, by Owned Landholding Size
Reverse tenancy

Figure 6. Within-Village Relationship Between the Probability of Leasing In and Leasing out Land, by Ownership Holdings (N=119,349)
Conclusions I

Substantial potential to release labor from agriculture and raise per worker productivity and per acre productivity.

- This is not due to labor market problems but to thinness of land market coupled with scale economies from mechanization and credit.
- In keeping with long tradition of thinness in land markets and high share of land transactions—both rental and sale—that are within family.
- Even if per-acre profitability of small farmers were the same, not clear that would remain so as wages rise through development.
- However, increases in scale without other opportunities and ability to hold assets would have substantial adverse impact on poor through labor market.
Key issue is what barriers are to consolidation/amalgamation

- Thinness of land markets
- Need for contiguous plots
- Poor have a collective incentive to reduce amalgamation
- Credit markets (value of land is tied to consolidation)
- Alternative mechanisms to store wealth/hedge risk
- Weak political/legal institutions
- Other non-financial barriers to land transactions