Mechanizing Agriculture: Impacts on Labor and Productivity

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Introduction

Mechanization is a primary feature of modern agriculture.

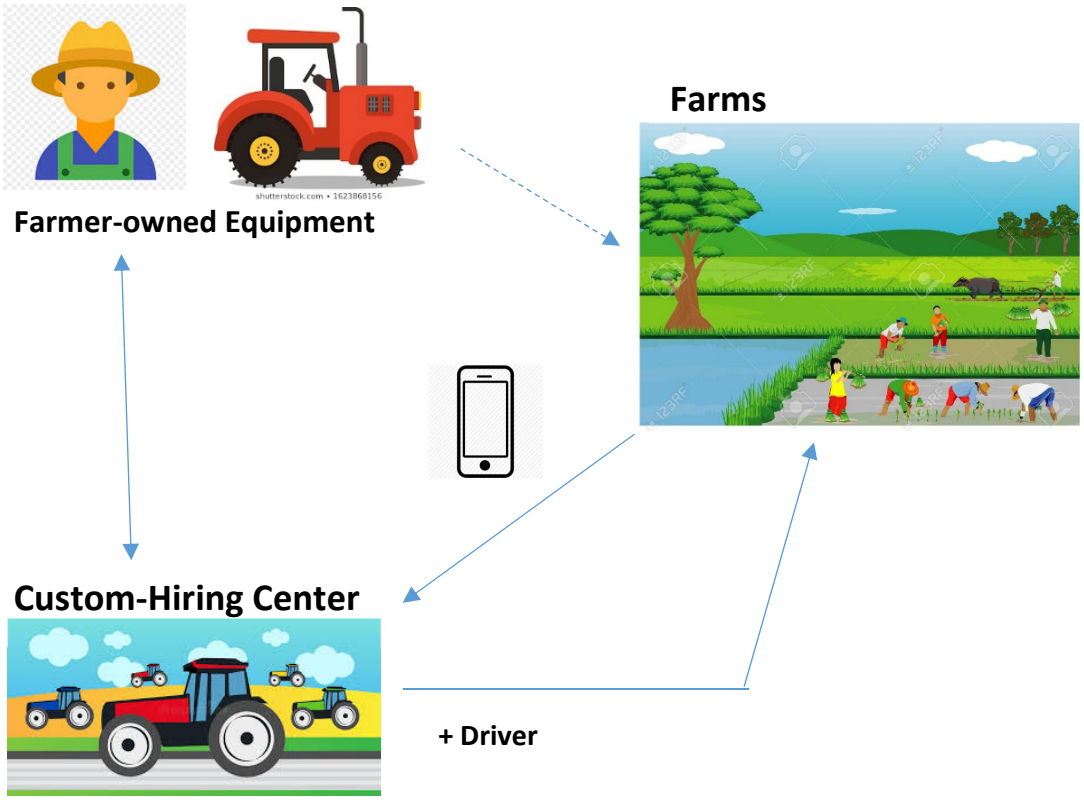
- *Significant automation technology,*
- *Increasing government subsidies aiming at increased mechanization.*

How does mechanization impact rural economies?

- *labor displacement effect,*
- *total factor productivity,*
- *farming households' income,*
- *marginal returns to mechanization?*

Rental market and our intervention

Karnataka, India



Rental market and our intervention

Karnataka, India

Farmer-owned Equipment

7000 **Farms**, 200 villages, 8 districts

Random Subsidy

Vouchers & Cash +

Information CHC

Custom-Hiring Center

+ Driver

Redeemed **anytime**
June-October 2019

High-quality transaction data

Estimating equation

$$y_i = \alpha + \beta \mathbb{1}[\text{Mechanization Voucher}_i] + \\ + \gamma \mathbb{1}[\text{Mechanization Voucher and Cash}_i] + \psi_1 y_{ib} + \psi_2 X_i + \epsilon_i$$

y_i outcome for farmer i.

β impact of the subsidy.

γ impact of **additional** cash transfer.

y_{ib} baseline controls (when available).

Not finding spillovers, we pool and include village fixed effects.

Mechanization for land-preparation

Voucher induces 1 additional hour of mech. relative to control.

	(1)	(2)
	IHS (Mechanization Index)	
1(Mechanization)	0.151***	0.152***
	(0.0326)	(0.0406)
1(Cash and Mechanization)		0.00156
		(0.0411)
Control Mean	-0.05 (6.8 hs)	-0.05 (6.8 hs)
Observations	5398	5360

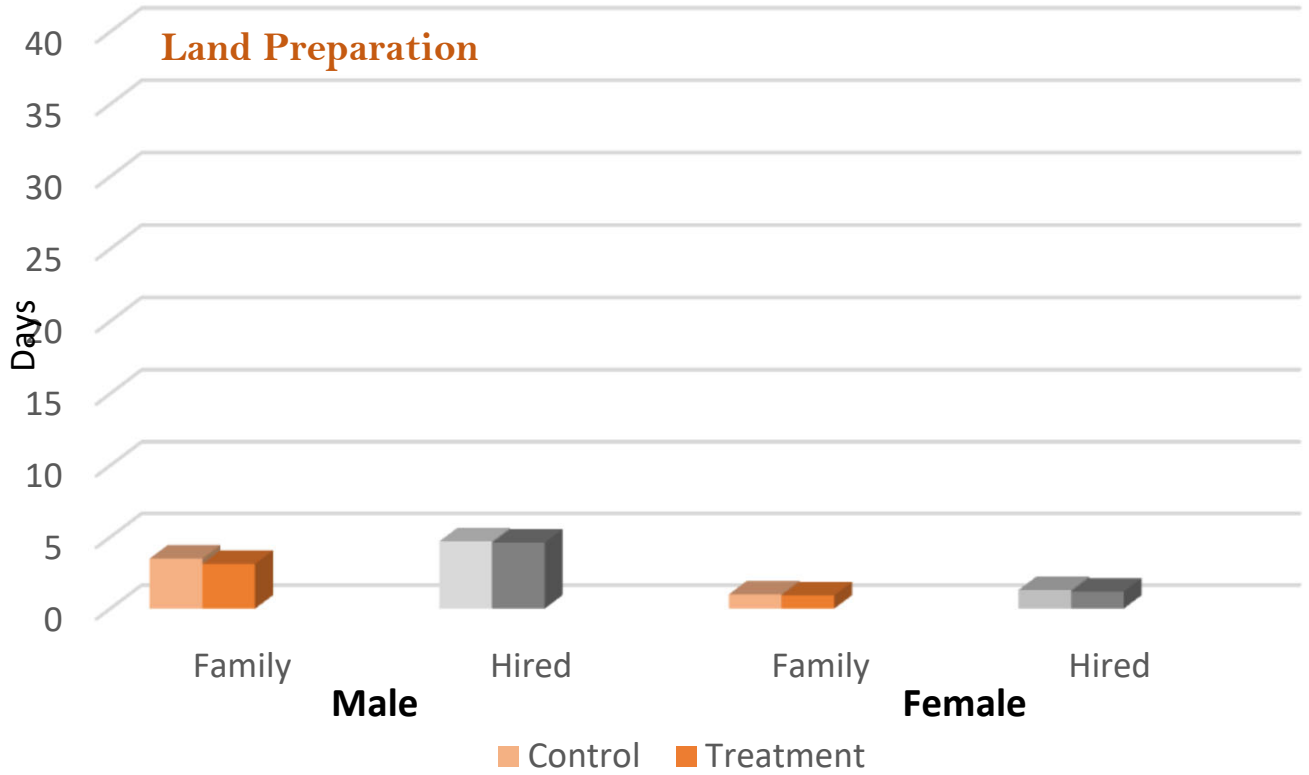
Standard errors clustered at the village-level in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

less than 3% of the sample reports mechanizing other stages and we find no significant treatment effects.

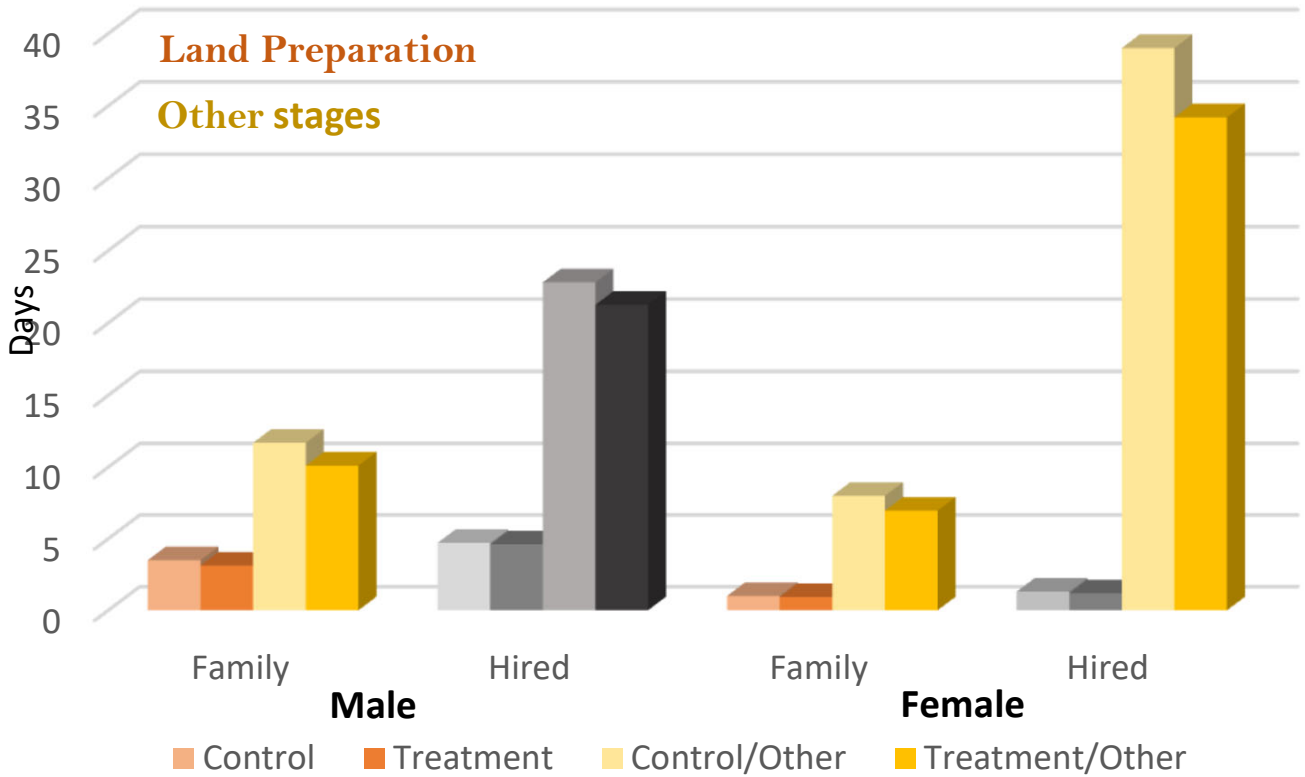
Differential labor effects

Family labor savings at preparation, 1 day of work.



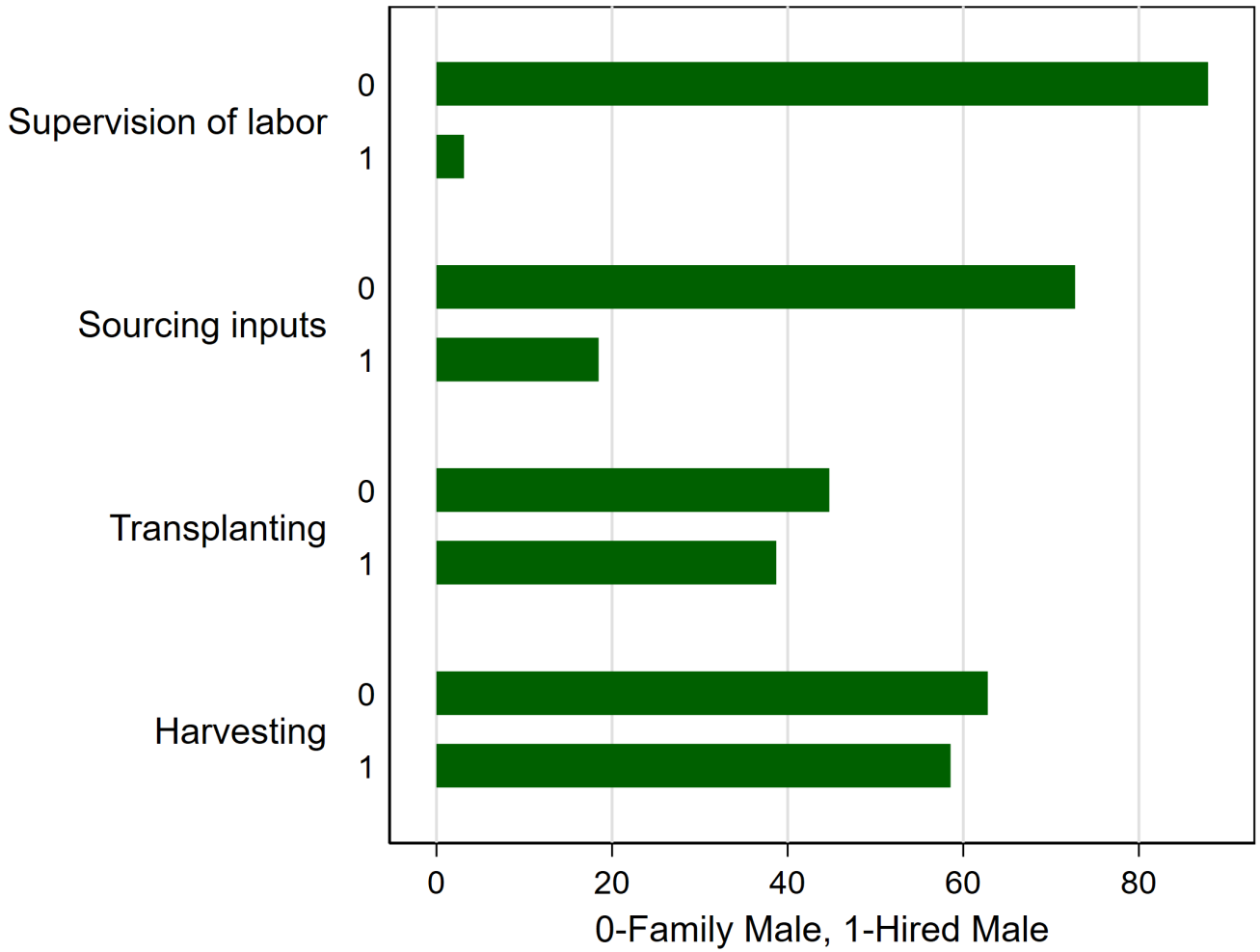
Differential labor effects

Hired labor savings later stages, 5 days of work.



Task Specialization

Family labor savings concentrated in members involved in supervision.



Detailed task information for 14,000 workers.

Non-agricultural income

Additional non-agricultural income worth season agric. wage.

	(1) 1(Any Non-Agricultural Income)	(2) Change in IHS (Non-Agricultural Income)
1(Mechanization)	0.0183	0.464**
	(0.0147)	(0.207)
1(Cash and Mechanization)	-0.00207	-0.0144
	(0.0168)	(0.239)
Control Mean Levels	0.310	533.7
Observations	5497	5409

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Implications:

Model of farming and mechanization to... ▸ go

- estimate the importance of channels,

  → *comparative advantage of capital to labor across tasks.*

  → *work on the farm, outside, hire labor and supervise.*

  → *size (and change) of the contracting friction for hired labor.*

- quantify returns to mechanization,

Conclusion

- Findings
  - returns to mechanizable tasks, 36%.
  - no changes in output/profits per acre.
  - returns to the subsidy, 28%.(income + input savings)

- Causal (short-run) impact of mechanization on labor and productivity.

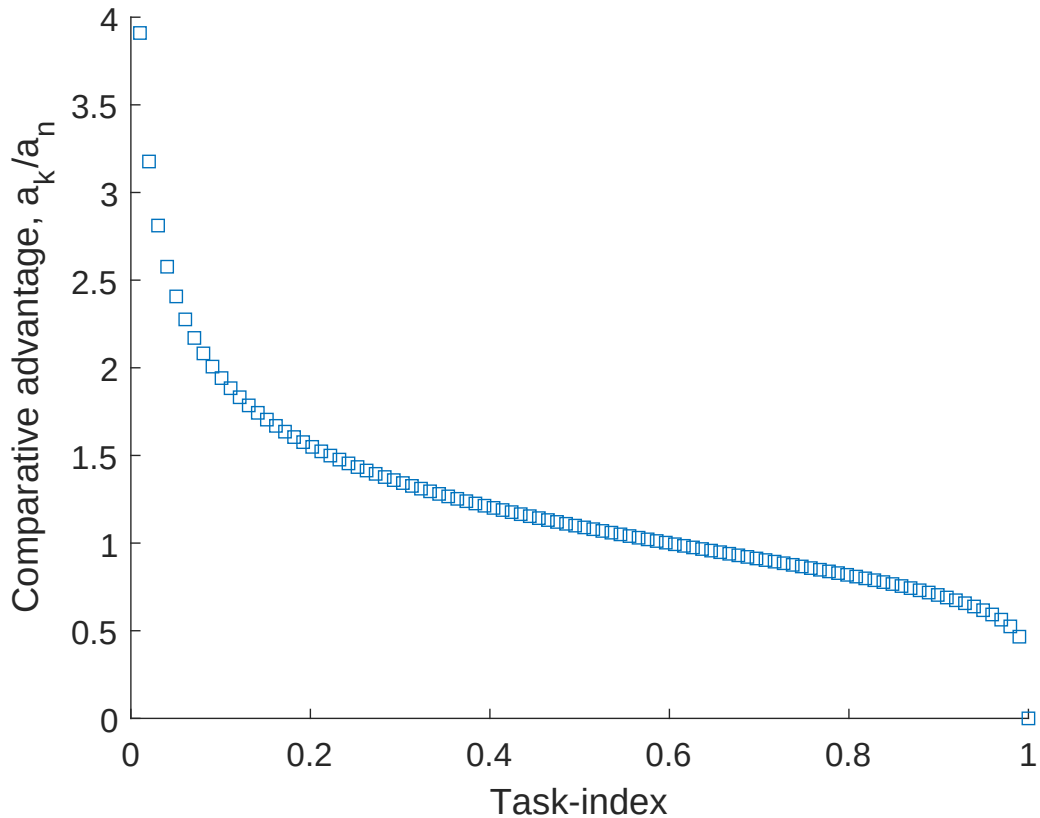
- Task specialization $\rightarrow$ heterogeneous impacts on labor.

  heterogeneous effects,
  general equilibrium.

A model of farming

- Tasks x_i, performed with either capital or labor

$$x_i = a_k(i)k(i) + a_n(i)n(i).$$



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Returns to mechanization?

$$\ln y = \ln TFP + \alpha I \ln(k) + \text{labor} + \text{land} + \text{other inputs}$$

- RCT impacts TFP $\rightarrow$ can't use treatment as IV αI

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- Parameters of interest:

  Returns to mechanizable tasks α
  Total Factor Productivity.
  Capital-Labor elasticity of substitution.

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- Parameters of interest:

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Bench-marking to Census

Census of over 41,000 farmers in 150 villages

	Intervention Sample		Census Sample	
	Mean	SD	Mean	SD
Land holdings (Acres)	3.56	2.8	3.78	4.8
Agricultural Revenue (000s)	48.435	86.48	48.209	74.07
1(Paddy)	.19	0.4	.2	.42
1(Cotton)	0.22	0.42	.23	.42
1(Maize)	0.16	0.37	0.17	0.38
Household Size	3.5	1.42	4.83	2.3
1(Commonly Rented Equipment)	0.94	0.24	0.85	0.35

Commonly rented implements: cultivator, rovatator, tractor, mechanical plough, disc plough, power tiller.

Take-Up

- Mechanization in CHC increases by 30%.
- Identical for endline sample and entire sample.

	(1)	(2)	(3)	(4)
	1(Matched to Platform)			
1(Mechanization)	0.310***	0.338***	0.307***	0.335***
	(19.00)	(18.66)	(16.98)	(16.53)
1(Cash and Mechanization)		-0.0569***		-0.0576***
		(-3.60)		(-3.47)
Endline Survey			X	X
Observations	7202	7161	5530	5492

t statistics in parentheses. Clustering at the village-level.

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Contracting frictions

- Workers' effort not contractible. Benefit from shirking, ωw_s.
- Family labor supervises and detects shirking w/prob. $\frac{n_f}{n_s}$.
- Incentive compatibility yields,

$$w_s \geq \omega w_s + \left(1 - \frac{n_f}{n_s}\right) w_s,$$

assume $\frac{n_f}{n_s} \leq 1$.

- The optimal family supervision effort

$$\frac{n_f}{n_s} = \omega$$

- Optimality for family labor and hired labor imply

$$\omega = \frac{\alpha_f}{\alpha} \frac{w_s}{w_f}$$

$\rightarrow$ wage differential proportional to incentives to shirk!

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