

Technological Change and Labor Use: Evidence from Indian Agriculture

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Employment in Rural India

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- Proportion of working age adults in farm sector in rural India fallen from 55% to 44%

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- Is there any role of the push factors?
 - falling labor demand in farm sector

Larger decline: Women in Agriculture

- Women's role in Indian agriculture is salient
 - Out of total labor force in farm sector rural labor in India, women made up 36% in 1999 and 32% in 2011
 - Over time, greater decline in their role in farm sector in India
 - Decline in their involvement in farm sector biggest contributor to their overall decline in labor force in rural India (49% in 1999 to 41% in 2011)

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 - Decline in their involvement in farm sector biggest contributor to their overall decline in labor force in rural India (49% in 1999 to 41% in 2011)
- Can the push factors have gender differentiated impacts?

Agricultural Labor Use over Time

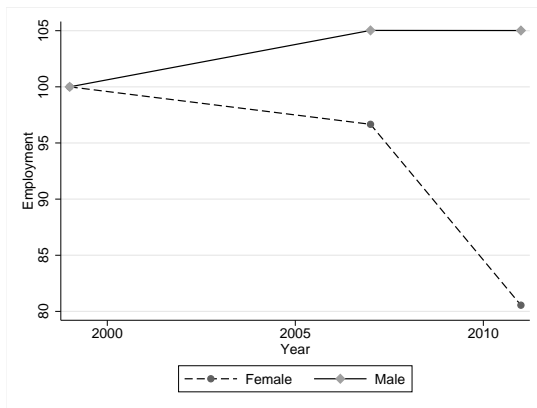


Figure: Labor use per hectare of land cultivated

Changing Technology in Cultivation

- Production processes changing over time
- Adoption of machines in cultivation tasks
- In this paper we will focus on mechanization in agriculture - one aspect of technological change

Drivers of Mechanization: Tractors and Power Tillers

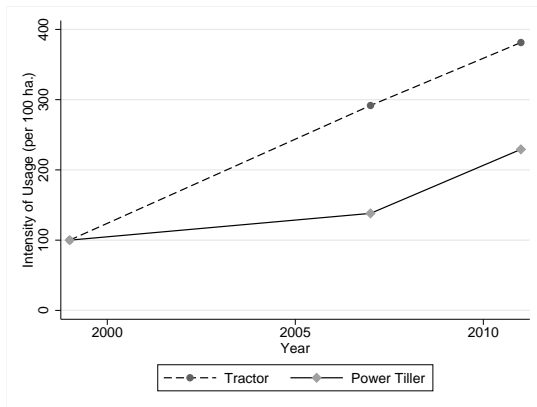


Figure: Growth in Tractors and Power Tillers over time

- Sequencing of tasks (Skoufias 1993)
 - Stage 1: Land preparation (primary or deep tillage and secondary or shallow tillage) and sowing
 - Stage 2: Intercultural operations (weeding)
 - Stage 3: Harvesting and post-harvest
 - Others (fertilization, irrigation) - throughout

Production Process in Cultivation

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 - Stage 3: Harvesting and post-harvest
 - Others (fertilization, irrigation) - throughout
- Complementarities across production tasks
 - For example: If tillage is done well, weed growth is restricted and the weeding labor requirement falls

Mechanization of Cultivation Operations

- Agricultural implements can be classified into:
 - Hand operated
 - Animal operated
 - **Power operated** (diesel, electric etc)
 - Tractor or PT driven
 - Self-propelled

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 - Hand operated
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 - Tractor or PT driven
 - Self-propelled
- Mechanization: Adoption of power operated implements
 - Tillage, Harvesting & Threshing are 'power' intensive (physical+manual power) operations while weeding is 'control' intensive (precision)
 - Power intensive first to be mechanized (Binswanger (1984))
 - We look at operation wise sources of power (tractors and power tillers excluded: can be used across operations)
 - Sum the area under all implements, for each type (hand, animal, power), across operations

Mechanization of Crop Production (All operations)

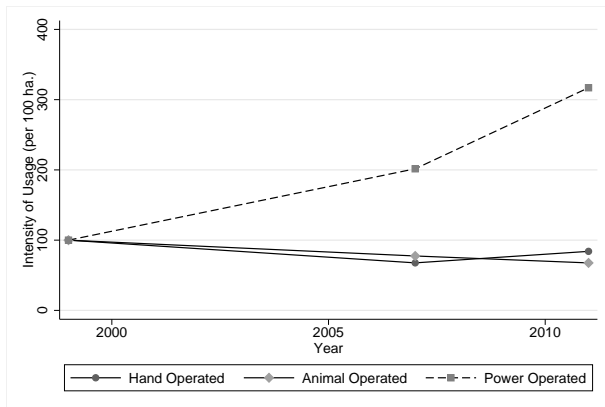
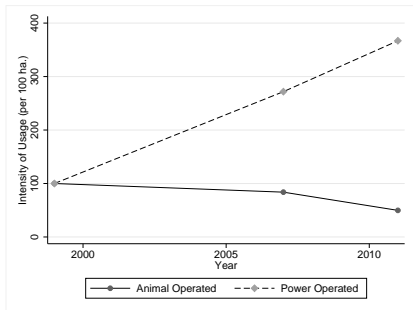


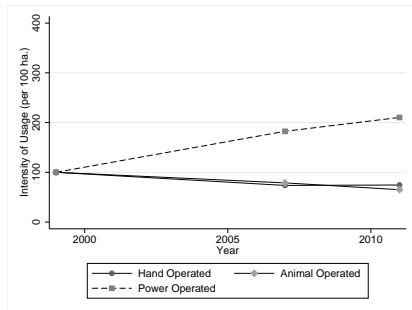
Figure: Implement Usage (source of power)

Mechanization of Crop Production (By operations)

Stage 1 (Tilling and sowing)



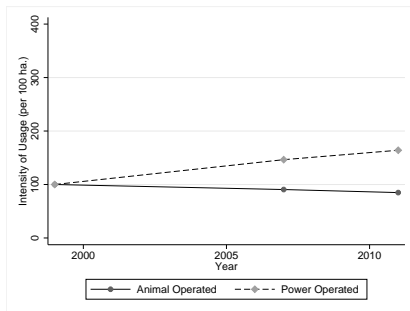
Stage 1: Primary Tilling



Stage 1: Secondary Tilling

Mechanization of Crop Production (By operations)

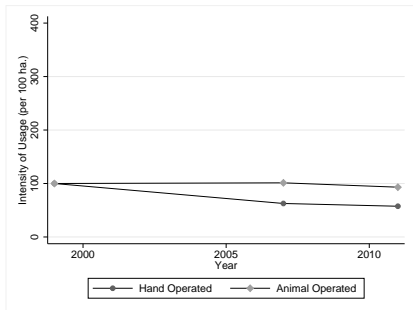
Stage 1 (Tilling and sowing)



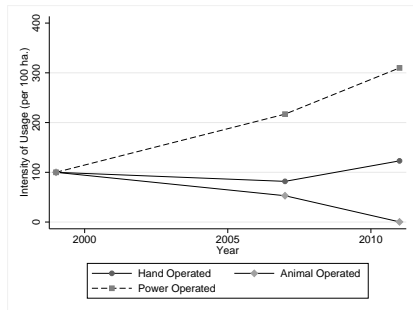
Stage 1: Sowing

Mechanization of Crop Production (By operations)

Stage 2 (Weeding) & Stage 3 (Harvesting & Threshing)

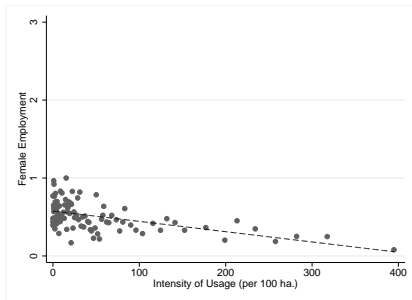


Stage 2: Weeding

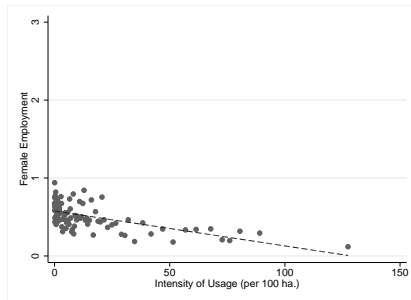


Stage 3: Harvesting & Threshing

Mechanization (by stage) and Female Employment

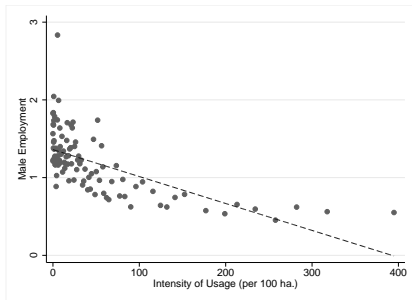


Stage 1 (Tilling & Sowing)

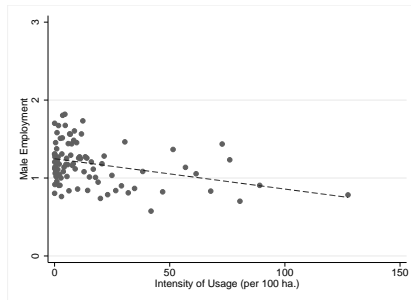


Stage 3 (Harvesting & Threshing)

Mechanization (by stage) and Male Employment



Stage 1 (Tilling & Sowing)



Stage 3 (Harvesting & Threshing)

- Pingali (2007): Tractor adoption
 - 22 of the 24 studies reviewed reported lower total labor use per hectare of crop production for tractor farms compared to draft animal farms
 - 12 studies reported reductions in labor use of 50% or more.
 - The greatest reduction in labor use was for land preparation followed by weeding

Mechanization of Land Preparation: Impact on Labor Use

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 - 12 studies reported reductions in labor use of 50% or more.
 - The greatest reduction in labor use was for land preparation followed by weeding
- Gender differentiated impacts have been ignored in the literature
 - Some evidence on mechanized threshers: lighter nature of the work made it possible for women and children to substitute for men (Ebron (1984))

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- Examine the effect of mechanization in land-preparation stage on labor use
 - Specifically, gender differentiated impacts
- Use an instrumental variable strategy to deal with endogeneity in adoption of machines for land preparation
 - Link between soil texture and deep tillage requirements
- Findings:
 - Overall - significant reduction in women labor employed in cultivation per hectare
 - Male labor employed also falls - but only family male - compensated by increase in hired labor use
 - Placebo checks show that results not driven by other factors

Mechanization of Land Preparation and Labor Use: Channels

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 - Land preparation with machines, deeper tillage of better quality can reduce weed growth, lower weeding labor (more women here)

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Table: Gender composition across tasks

	Ploughing	Sowing	Weeding	Harvesting	Other
Proportion Females	21%	24%	26%	25%	24%

- Compile district level data using a variety of sources
 - Soil characteristics: digitize soil maps of India to get information on soil texture, Ph, Depth, Slope
 - Mechanization: Agricultural Input Censuses (1997-99, 2006-07 and 2011-12)
 - Employment: National Sample Survey (1999, 2007, 2011)
 - Other agri controls: Crop composition, rainfall, temperature, irrigation, landholding size, urban population (land use, APY statistics, census of India)
 - Demographic controls, input controls, development controls (NSS, census of India, input census, fertilizer association of India, DMSP)

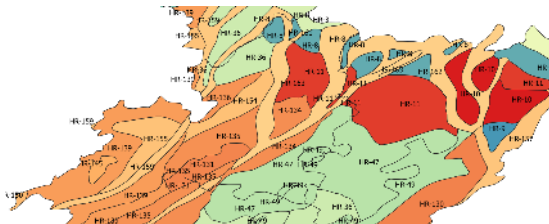


Figure: Haryana Map (1)

Source: National Bureau of Soil Survey (1995-98) Maps

Soil (surface texture): District level variation

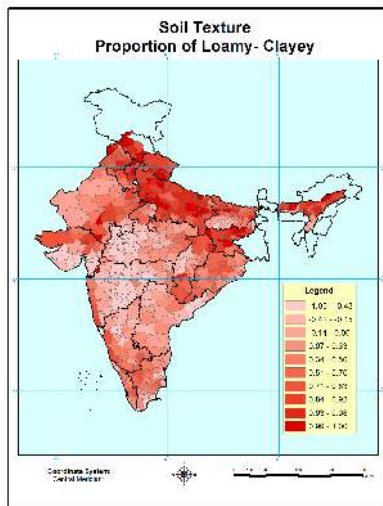


Figure: (%Loamy-%Clayey)

Source: Digitized by authors from National Bureau of Soil Survey (1995-98) Maps

Data: Mechanization

- Input census: area cultivated under each of the implements in that agricultural year
- Classification: three categories depending on the source of energy used - hand, animal and power operated (electrical and mechanical power)

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 - Harvesting & Threshing: combined harvester (self-propelled & trailed), thresher, reaper (Trailed is 11%)

Mechanization: District level variation

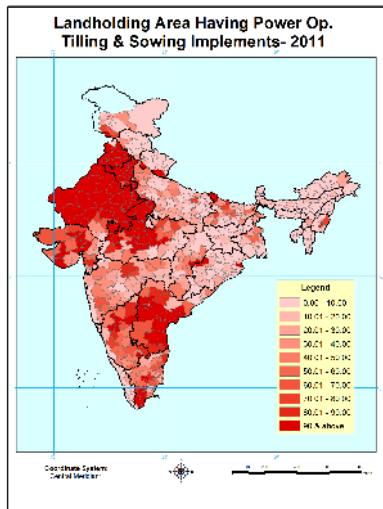


Figure: Stage 1(Tilling & Sowing)

Data: Summary statistics

Variable	Definition	Mean	SD
Employment (age 15-65):			
Female Employment	Females working in cultivation/area under cultivation	.512	.385
Male Employment	Males working in cultivation/area under cultivation	1.19	.686
Implements:			
Primary Tilling	Intensity of usage primary tilling implements/100ha	19.2	28.6
Secondary Tilling	Intensity of usage secondary tilling implements/100ha	19.4	28.7
Sowing	Intensity of usage sowing implements/100ha	10.1	21.2
Harvesting & Threshing	Intensity of harvesting & threshing implements/100ha	14.4	22.9
Soil texture			
Sandy	Proportion of soil with sandy texture	.094	.165
Loamy	Proportion of soil with loamy texture	.631	.278
Clayey	Proportion of soil with clayey texture	.274	.276

Data: Summary statistics (Controls)

Variable	Definition	Mean	SD
Initial Employment (1993-94) (Age 15-65):			
Female Employment	Females working in cultivation/area under cultivation	.682	0.716
Male Employment	Males working in cultivation/area under cultivation	1.46	1.34
Agriculture			
Soil Characteristics:			
Depth	Average depth of soil (cm)	109	25.6
Slope	Average slope/gradient of soil (%)	4.65	4.03
pH	Average soil pH	7.3	.864
Crop Composition (Proportion):			
Wheat	Area under wheat	.167	.184
Rice	Area under rice	.336	.284
Coarse cereals	Area under coarse cereals	.134	.158
Pulses	Area under pulses	.103	.103
Oil seeds	Area under oil seeds	.105	.134
Fruits & Vegetables	Area under fruits & vegetables	.0299	.0526
Other	Area under other crops	.126	.163
Climate:			
Rainfall	Yearly Precipitation(mm): All Months	1204	684
Temperature	Yearly Mean Temperature (°C)	25.6	1.55
Miscellaneous:			
Urban population	Proportion of urban population	.235	.154
Average landholding	Average size of landholding (ha)	1.38	1.15
Irrigated Area	Proportion of Net Sown Area under irrigation	.497	.289

Data: Summary statistics (Controls)

Variable	Definition	Mean	SD
Demographic			
Caste (Proportion):			
ST	Scheduled Tribes population	.102	.173
SC	Scheduled Castes population	.21	.117
OBC	Other Backward Castes population	.427	.218
Others	Other castes population	.261	.199
Religion (Proportion):			
Hindu	Hindu population	.852	.176
Muslim	Muslim population	.104	.137
Christian	Christian population	.0165	.0552
Others	Other religions population	.0276	.115
Female Education (Proportion age 15-65):			
Illiterate	Females who are illiterate	.534	.193
Up to Secondary	Females educated up to secondary school level	.410	.165
Higher Sec above	Females educated up to higher secondary level & above	.0556	.0520
Male Education (Proportion age 15-65):			
Illiterate	Males who are illiterate	.286	.141
Up to Secondary	Males educated up to secondary school level	.594	.121
Higher Sec above	Males educated up to higher secondary level & above	.120	.0659

Data: Summary statistics (Controls)

Variable	Definition	Mean	SD
Agricultural Input			
Fertilizer:			
Nitrogenous	Fertilizer consumption (kg/'000 ha)	.118	.0961
Phosphorous	Fertilizer consumption (kg/'000 ha)	.0477	.0353
Potash	Fertilizer consumption (kg/'000 ha)	.0214	.0251
Pesticides	Proportion of total cropped area using pesticides	.34	.268
Credit	Total short, long and medium term credit (Rs/'000 ha)	3784	5284
Development			
Approach road	Proportion of villages with paved approach road	.83	.175
Night lights	Annual relative night-time luminosity (0-63)	4.86	3.86

Empirical Strategy: IV Estimation

$$L_{dst}^F = \beta_0 + \beta_1 MC_{dst} + X_{dst}\beta_2 + D_s + D_t + \epsilon_{dst}$$

$$L_{dst}^M = \beta_0 + \beta_1 MC_{dst} + X_{dst}\beta_2 + D_s + D_t + \epsilon_{dst}$$

- Here, d refers to district, in state s at time t and the superscript refers to male employment (M) and female employment (F).
- The dependent variable is labor employment per unit of cultivated land (L).
- The variables MC captures mechanization in Stage 1: *Tillage & Sowing*.
- X_{dst} are other district level controls,
- D_s are state fixed effects and D_t are time fixed effects.
- Since MC is likely to be endogenous, we instrument for it using the difference in loamy and clayey composition of the soil.

Empirical Strategy: IV Estimation (First Stage)

$$MC_{dst} = \pi_0 + \pi_1(Loamy - Clayey)_{ds} + X_{dst}\pi_2 + D_s + D_t + \epsilon_{dst}$$

Here, *Soil Texture* is defined as the difference in the proportion of loamy and clayey soils in district d , in state s . Since this is an initially given endowment, it does not vary over time.

Instrumental Variable

- The most power intensive operation within tillage is deep tillage - generally more than 45 inch of soil is turned over in primary tillage operations (Dunker et al. 1994)
 - These are followed by secondary tillage or directly by sowing
- Primary tillage likely the first to be mechanized: tractor driven ploughing implements
 - Primary tillage is not possible on all types of soil - loamy soils are more amenable for deep tillage while increasing clay content is suitable for shallow tillage (Wildman (1981); Müller, Lothar and Schindler (1999))
- Once tractors have been adopted to meet the need for primary tillage, possible that shallow tillage and sowing operations are mechanized too (use tractor driven implements)

Effect of Soil Texture on Mechanization: By Stage

	(1) Tractor Driven Tilling & Sowing	(2) Self-propelled Harvesting & Threshing
Loamy-Clayey Soils	13.79*** (3.40)	-0.429 (-0.24)
Constant	-67.15 (-0.70)	14.52 (0.35)
FS F-Stat	11.56	0.0585
R^2	0.693	0.549
N	1077	1077

Note: All specifications have State and Year Fixed Effects and Initial Values of employment; Controls for agriculture, demographic, agricultural inputs and development. Robust standard errors clustered at the district level in parentheses

The measure of mechanization: power operated implements adoption in Primary tillage, Secondary tillage and Sowing (Tilling & Sowing)

Effect of Soil Texture on Mechanization: Operations in Stage 1

	Tilling & Sowing		
	(1)	(2)	(3)
	Primary Tilling	Secondary Tilling	Sowing
Loamy-Clayey Soils	6.223*** (3.47)	5.519*** (3.26)	2.044# (1.63)
Constant	10.06 (0.23)	-47.50 (-1.19)	-29.71 (-1.08)
FS F-Stat	12.02	10.63	2.645
R ²	0.610	0.657	0.679
Observations	1077	1077	1077

Note: All specification have State and Year Fixed Effects and Initial Values of employment; Controls for agriculture, demographic, agricultural inputs and development. Robust standard errors clustered at the district level in parentheses

Instrumental Variable: Exogeneity

- Soil texture may have direct effects on employment, especially by women, if historically women were more disadvantaged in areas requiring more primary tillage which is a physically intensive operation (Carranza 2014)

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- Soil texture may have direct effects on employment, especially by women, if historically women were more disadvantaged in areas requiring more primary tillage which is a physically intensive operation (Carranza 2014)
- Historical geographic conditions affecting type of crops grown can affect current norms on women's employment (Alesina, Giuliano and Nunn 2013).
- The districts which saw greater machine adoption could also have seen greater economics growth, thus affecting women's and men's employment in agriculture

Instrumental Variable: Exogeneity

- We address the above concerns by including controls for:
 - Initial agricultural employment levels 1993 (for men and women)
 - Other soil characteristics that affect crop choice and current crop composition
 - Nightlights
- Additionally, control for trends due to initial differences in employment across regions

Result: Effect of Mechanization on Employment

	(1)	(2)	(3)	(4)
<i>Panel A: Female Employment</i>				
Tilling & Sowing	-0.008*	-0.009**	-0.008**	-0.007**
	(0.004)	(0.004)	(0.003)	(0.003)
Observations	1,077	1,077	1,077	1,077
FS F-Stat	6.581	8.540	11.99	11.56
Mean (DV)	0.520	0.520	0.520	0.520
<i>Panel B: Male Employment</i>				
Tilling & Sowing	-0.002	-0.002	-0.001	-0.001
	(0.004)	(0.004)	(0.004)	(0.004)
Observations	1,077	1,077	1,077	1,077
FS F-Stat	6.747	8.165	11.19	10.91
Mean (DV)	1.078	1.078	1.078	1.078
Chi ² p-value				0.1818
Agriculture Controls	YES	YES	YES	YES
Demographic Controls	NO	YES	YES	YES
Agri-Input Controls	NO	NO	YES	YES
Development Controls	NO	NO	NO	YES

Note: All specification have State and Year Fixed Effects and Initial Values of employment; Robust standard errors clustered at the district level in parentheses

Robustness: Effect of Mechanization on Employment

	(1)	(2)	(3)	(4)
	<i>Female Employment</i>		<i>Male Employment</i>	
Tilling & Sowing	-0.007** (0.003)	-0.006** (0.003)	-0.001 (0.004)	0.000 (0.003)
Observations	1,077	1,077	1,077	1,077
FS F-Stat	11.67	14.43	11.35	14.33
Mean (DV)	0.520	0.520	1.078	1.078
<i>Additional Controls</i>				
Initial District Employment \times Time	YES	YES	YES	YES
State \times Time	NO	YES	NO	YES

Note: All specifications have State and Year Fixed Effects and Initial Values of employment; Controls for agriculture, demographic, agricultural inputs and development. Robust standard errors clustered at the district level in parentheses

Heterogeneity: Effect of Mechanization on Employment

	(1) Overall	(2) Self-Employed	(3) Casual
<i>Panel A: Female Employment</i>			
Tilling & Sowing	-0.007** (0.003)	-0.006** (0.003)	-0.001 (0.001)
Observations	1,077	1,077	1,077
FS F-Stat	11.56	11.56	11.56
Mean (DV)	0.520	0.332	0.239
<i>Panel B: Male Employment</i>			
Tilling & Sowing	-0.001 (0.004)	-0.007** (0.004)	0.006# (0.004)
Observations	1,077	1,077	1,077
FS F-Stat	10.91	10.91	10.91
Mean (DV)	1.078	0.770	0.402
Chi ² p-value	0.1818	0.6289	0.0740

Note: All specifications have State and Year Fixed Effects and Initial Values of employment; Controls for agriculture, demographic, agricultural inputs and development. Robust standard errors clustered at the district level in parentheses

Mechanism: Effect of Mechanization on Employment

	(1) Ploughing	(2) Sowing	(3) Weeding	(4) Harvesting	(5) Other
<i>Panel A: Female Employment</i>					
Tilling & Sowing	-0.004 (0.006)	-0.004 (0.006)	-0.012# (0.007)	-0.006 (0.006)	-0.002 (0.007)
Observations	1,077	1,077	1,077	1,077	1,077
FS F-Stat	11.56	11.56	11.56	11.56	11.56
Mean (DV)	0.701	0.811	0.905	0.976	1.183
<i>Panel B: Male Employment</i>					
Tilling & Sowing	0.023 (0.023)	0.017 (0.022)	0.011 (0.021)	0.019 (0.022)	0.023 (0.025)
Observations	1,077	1,077	1,077	1,077	1,077
FS F-Stat	10.91	10.91	10.91	10.91	10.91
Mean (DV)	2.631	2.553	2.613	2.934	3.821

Note: All specifications have State and Year Fixed Effects and Initial Values of employment; Controls for agriculture, demographic, agricultural inputs and development. Robust standard errors clustered at the district level in parentheses

Placebo: Effect of Mechanization on Other Employment

	(1)	(2)	(3)	(4)	(5)	(6)
<i>Panel A: Female Employment</i>						
	<i>Rural</i>			<i>Both Rural & Urban</i>		
	Manu	Cons	Serv	Manu	Cons	Serv
Tilling & Sowing	0.000 (0.001)	0.001 (0.001)	0.001 (0.001)	0.000 (0.001)	0.001 (0.001)	0.001 (0.001)
Observations	1,077	1,077	1,077	1,077	1,077	1,077
FS F-Stat	11.56	11.56	11.56	11.56	11.56	11.56
Mean (DV)	0.0850	0.0628	0.0980	0.105	0.0603	0.151
<i>Panel B: Male Employment</i>						
	<i>Rural</i>			<i>Both Rural & Urban</i>		
	Manu	Cons	Serv	Manu	Cons	Serv
Tilling & Sowing	-0.000 (0.001)	0.001 (0.001)	-0.000 (0.001)	-0.001 (0.001)	0.001 (0.001)	-0.000 (0.001)
Observations	1,077	1,077	1,077	1,077	1,077	1,077
FS F-Stat	10.91	10.91	10.91	10.91	10.91	10.91
Mean (DV)	0.0963	0.134	0.193	0.119	0.130	0.274

Note: All specifications have State and Year Fixed Effects and Initial Values of employment; Controls for agriculture, demographic, agricultural inputs and development. Robust standard errors clustered at the district level in parentheses

- Increase in intensity of primary tillage by one unit decreases women's employment by 0.008 persons per hectare, approx. 1.5% (Log specification shows a decline by 2%)
- Increase in usage intensity of tilling & sowing mechanized equipment in Indian agriculture from 20 in 1999 to 62 in 2011.
- Implies an increase of 40 intensity units during this period, so a reduction in women's employment in cultivation by 60% ceteris paribus.
- Overall effect on men is insignificant though negative, self-employed male labor on own farm falls by 1% with every one unit increase in mechanization but male casual labor increases by 1.5%
- Test shows a significant reduction in women's labor relative to men's labor only for hired labor

Other Impacts of Mechanization

- Yield: Rice (0.2%), wheat(1%), Coarse cereals (0.5%) marginally significant for only wheat [▶ Go to results](#)
- Cropping Intensity: Positive but insignificant [▶ Go to results](#)
- Wage (casual labor in cultivation): Female (0.6%), Male (0.5%) - significant [▶ Go to results](#)
- Household MPCE: Positive and significant (0.3%) [▶ Go to results](#)

Conclusion

- Labor use per hectare fall for both men and women for family labor, while casual labor relative fall for female labor
- The results for women driven by fall in labor requirement in weeding
- So is mechanization in agriculture welfare reducing?
 - Positive but insignificant effect on yield and cropping intensity
 - Positive and significant effect for casual labor wages - possible when marginal productivity of labor increase as more capital is used
 - Positive effect on consumer expenditure of households

Appendix

Appendix: Effect of Mechanization on Employment (Log)

	(1)	(2)	(3)	(4)
<i>Panel A: Log Female Employment</i>				
Tilling & Sowing	-0.022# (0.014)	-0.026* (0.014)	-0.022** (0.011)	-0.021* (0.011)
Observations	1,066	1,066	1,066	1,066
FS F-Stat	5.518	7.979	11.74	11.35
Mean (DV)	-1.045	-1.045	-1.045	-1.045
<i>Panel B: Log Male Employment</i>				
Tilling & Sowing	0.002 (0.004)	0.001 (0.004)	0.000 (0.003)	0.000 (0.003)
Observations	1,066	1,066	1,066	1,066
FS F-Stat	5.787	7.477	10.92	10.68
Mean (DV)	-0.0802	-0.0802	-0.0802	-0.0802
Chi ² p-value				0.0577
Agriculture Controls	YES	YES	YES	YES
Demographic Controls	NO	YES	YES	YES
Agri-Input Controls	NO	NO	YES	YES
Development Controls	NO	NO	NO	YES

Note: All specification have State and Year Fixed Effects and Initial Values of employment; Robust standard errors clustered at the district level in parentheses

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Appendix: Effect of Mechanization on Employment (Robustness) (Log)

	(1)	(2)	(3)	(4)
	<i>Log Female Employment</i>		<i>Log Male Employment</i>	
Tilling & Sowing	-0.021*	-0.018*	0.001	0.002
	(0.011)	(0.009)	(0.003)	(0.003)
Observations	1,066	1,066	1,077	1,077
FS F-Stat	11.51	14.15	11.35	14.33
Mean (DV)	-1.045	-1.045	-0.0790	-0.0790
<i>Trends</i>				
Initial Employment \times Time	YES	YES	YES	YES
State \times Time	NO	YES	NO	YES

Note: All specifications have State and Year Fixed Effects and Initial Values of employment; Controls for agriculture, demographic, agricultural inputs and development. Robust standard errors clustered at the district level in parentheses

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Appendix: Effect of Mechanization on Employment (Heterogeneity) (Log)

	(1) Overall	(2) Self-Employed	(3) Casual
<i>Panel A: Log Female Employment</i>			
Tilling & Sowing	-0.021* (0.011)	-0.023** (0.012)	0.003 (0.008)
Observations	1,066	1,037	945
FS F-Stat	12.31	11.71	11.22
Mean (DV)	-1.045	-1.597	-1.929
<i>Panel B: Log Male Employment</i>			
Tilling & Sowing	0.000 (0.003)	-0.004 (0.004)	0.013* (0.007)
Observations	1,066	1,066	1,021
FS F-Stat	10.68	10.68	13.23
Mean (DV)	-0.0802	-0.470	-1.312
Chi ² p-value			

Note: All specifications have State and Year Fixed Effects and Initial Values of employment; Controls for agriculture, demographic, agricultural inputs and development. Robust standard errors clustered at the district level in parentheses

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Appendix: Effect of Mechanization on Employment (by Operation) (Log)

	(1)	(2)	(3)	(4)	(5)
	Ploughing	Sowing	Weeding	Harvesting	Other
<i>Panel A: Log Female Employment</i>					
Tilling & Sowing	-0.013 (0.019)	-0.022 (0.020)	-0.041* (0.023)	-0.012 (0.011)	-0.013 (0.010)
Observations	658	812	846	962	1,010
FS F-Stat	3.746	3.645	5.381	8.948	10.95
Mean (DV)	-1.245	-0.903	-0.672	-0.616	-0.381
<i>Panel B: Log Male Employment</i>					
Tilling & Sowing	0.011 (0.010)	0.006 (0.008)	0.001 (0.007)	0.004 (0.005)	0.003 (0.004)
Observations	948	915	916	1,019	1,073
FS F-Stat	7.512	7.677	8.283	10.94	11
Mean (DV)	0.0186	-0.0972	0.0764	0.438	1.044

Note: All specifications have State and Year Fixed Effects and Initial Values of employment; Controls for agriculture, demographic, agricultural inputs and development. Robust standard errors clustered at the district level in parentheses

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Appendix: Effect of Mechanization on Yield (Log)

	(1)	(2)	(3)
	Rice	Wheat	Coarse Cereals
	<i>Log Yield</i>		
Tilling & Sowing	0.002 (0.004)	0.010# (0.007)	0.005 (0.004)
Observations	976	803	953
FS F-Stat	9.272	2.385	8.067
Mean (DV)	0.688	0.785	0.388

Note: All specifications have State and Year Fixed Effects and Initial Values of Yield; Controls for agriculture, demographic, agricultural inputs and development. Robust standard errors clustered at the district level in parentheses

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Appendix: Effect of Mechanization on Cropping Intensity

	(1)	(2)	(3)	(4)
Tilling & Sowing	0.012 (0.200)	-0.008 (0.209)	0.022 (0.222)	0.025 (0.231)
Observations	1,077	1,077	1,077	1,077
FS F-Stat	8.686	10.65	14.46	13.22
Mean (DV)	139.5	139.5	139.5	139.5
Agriculture Controls	YES	YES	YES	YES
Demographic Controls	NO	YES	YES	YES
Agri-Input Controls	NO	NO	YES	YES
Development Controls	NO	NO	NO	YES

Note: Cropping intensity is calculated as ratio of Gross Cropped Area over Net Sown Area. All specifications have State and Year Fixed Effects and Initial Values of Cropping Intensity from NSS's 50th round; Robust standard errors clustered at the district level in parentheses

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Appendix: Effect of Mechanization on Wage (Log)

	(1)	(2)	(3)	(4)
<i>Log Female Cultivation Wage</i>				
Tilling & Sowing	0.006*	0.007*	0.006**	0.006**
	(0.004)	(0.004)	(0.003)	(0.003)
Observations	812	812	812	812
FS F-Stat	5.433	5.416	8.811	9.054
Mean (DV)	4.400	4.400	4.400	4.400
<i>Log Male Cultivation Wage</i>				
Tilling & Sowing	0.005#	0.006*	0.005*	0.005*
	(0.003)	(0.003)	(0.003)	(0.003)
Observations	977	977	977	977
FS F-Stat	6.356	7.214	11.69	11.31
Mean (DV)	4.659	4.659	4.659	4.659
Chi ² p-value				0.7753
Agriculture Controls	YES	YES	YES	YES
Demographic Controls	NO	YES	YES	YES
Agri-Input Controls	NO	NO	YES	YES
Development Controls	NO	NO	NO	YES

Note: All specification have State and Year Fixed Effects and Initial Values of wage from NSS's 50th round; Robust standard errors clustered at the district level in parentheses

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Appendix: Effect of Mechanization on Total Labor

	(1)	(2)	(3)	(4)
<i>Panel A: Total Female Employment</i>				
Tilling & Sowing	645.404 (1,133.008)	222.586 (1,078.826)	105.214 (980.440)	81.144 (1,000.622)
Observations	1,077	1,077	1,077	1,077
FS F-Stat	7.385	9.450	12.33	11.91
Mean (DV)	211546	211546	211546	211546
<i>Panel B: Total Male Employment</i>				
Tilling & Sowing	2,168.923# (1,487.788)	1,473.775 (1,354.818)	1,323.517 (1,231.431)	1,330.570 (1,250.505)
Observations	1,077	1,077	1,077	1,077
FS F-Stat	7.660	8.911	11.89	11.53
Mean (DV)	373992	373992	373992	373992
Chi ² p-value				
Agriculture Controls	YES	YES	YES	YES
Demographic Controls	NO	YES	YES	YES
Agri-Input Controls	NO	NO	YES	YES
Development Controls	NO	NO	NO	YES

Note: All specifications have State and Year Fixed Effects and Initial Values of total employment; Robust standard errors clustered at the district level in parentheses

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Appendix: Effect of Mechanization on MPCE (Log)

	(1)	(2)	(3)	(4)
	<i>Log MPCE</i>			
Tilling & Sowing	0.002 (0.002)	0.003** (0.002)	0.003** (0.001)	0.003** (0.001)
Observations	1,077	1,077	1,077	1,077
FS F-Stat	7.036	8.722	12.05	11.83
Mean (DV)	6.980	6.980	6.980	6.980
Agriculture Controls	YES	YES	YES	YES
Demographic Controls	NO	YES	YES	YES
Agri-Input Controls	NO	NO	YES	YES
Development Controls	NO	NO	NO	YES

Note: All specifications have State and Year Fixed Effects and Initial Values of MPCE from NSS's 50th round; Robust standard errors clustered at the district level in parentheses

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