Impact of weather on wages and employment in rural India, 2004-2011.

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Motivation

- The incidence of droughts is frequent and lasts longer.
  Plot Drought
- Drought negatively affects crop yields and hence agricultural incomes. Coefplot Yield
- Increasing trend in the percentage of subsistence households and wage is the only source of livelihood.
  Plot Marginal Farmer Table Land holdings Plot workers from subsistence hhs
- What are the labor impacts of rainfall variability in rural India for the period 2004-2011?

Relationship to previous work

- A higher temperature negatively affects crop yields and agricultural incomes (Schlenker and Robert, 2009; Taraz, 2018).
- How labor market responds to weather shocks in low and middle incoming countries through the channel of agriculture?
  - Short-term increase in temperature is negatively associated with rural labor employment and labor reallocate from ag to non-ag sector (Jessose et al. 2016; Colmer 2018).
  - Rainfall shock results in lower wages in rural economies. (Jayachandran, 2006).

Contribution to the climate and development literature

- We explore a non-linear relationship between weather variables and labor demographics.
- A new data set that integrates spatial distribution of agro-climatic variables within a district with the national employment and unemployment situation.
- A critical examination of the relationship between rainfall variability and employment.

Profit Maximization Problem

Two types of agents: a single commercial farmer and n subsistence households. A commercial farmer with Cobb-Douglas production function $Q = Q(L, \bar{K}; \theta)$ with constant returns to scale.

$$Q = aL^{1-\alpha} \quad \text{where } a = A\bar{K}^{\alpha} \text{ and } \alpha \in (0,1).$$

For a given wage, w, and output price, p, the profit maximization implies that

$$p\frac{\partial \pi}{\partial L} = w => w = \frac{p(1-\alpha)a}{L^{\alpha}} => L^{*} = \left[\frac{p(1-\alpha)a}{w}\right]^{\frac{1}{\alpha}}$$

Taking logs and differentiating, we obtain the labor demand elasticity,

$$\frac{\partial ln(L)}{\partial ln(w)} = -\frac{1}{\alpha}.$$

Plot Estimated Labor Demand Elasticity

Labor reallocation decision: Set up

Following (Maggie Y. Liu et al., 2021), assume that there are two sectors: ag (A) and non-ag (N) in a two period model. The wage of individual i in sector $J (J = A, N)$ is given by:

$$w_i^J = \mu^J + \beta^J \varepsilon_i,$$

Baseline wage depends on climatic determinants, θ, through agricultural productivity. That is, $\mu^J = \mu^J(\theta)$ and $\frac{\partial \mu^A}{\partial \theta} < \frac{\partial \mu^N}{\partial \theta} < 0$.

Switching cost, $c = c(c_{monetary}, c_{non-monetary})$, from sector A to N in period 2. So,

$$\mu^N(\theta) + \beta^N \varepsilon_i - c > \mu^A(\theta) + \beta^A \varepsilon_i$$

Rearranging, we get:

$$\varepsilon_i > \frac{\mu^A(\theta) - \mu^N(\theta) + c}{\beta^N - \beta^A}.$$

Labor reallocation constraints: Incentive and Feasibility

Incentive constraint defined as

$$\frac{Mig}{Pop} = 1 - \Phi\left(\frac{\mu^A(\theta) - \mu^N(\theta) + c}{\beta^N - \beta^A}\right) \tag{1}$$

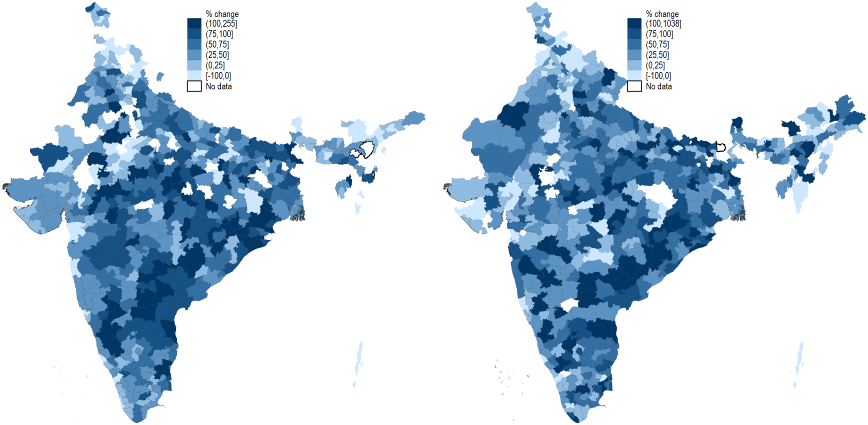
Feasibility constraint defined as

$$\frac{Mig}{Pop} = 1 - \Phi\left(\frac{c - \mu^A(\theta)}{\beta^A}\right) \tag{2}$$

By taking logarithms and log-linearizing both sides of equations 1 and 2, we obtain the basic empirical equation:

$$ln\left(\frac{Mig}{Pop}\right) = \alpha + \beta ln(\theta) + \gamma c.$$

District level percentage change in rural average day wage in real terms, NSS EUS, 2004-11



(a) Casual wage labor: Agriculture

(b) Casual wage labor: Non-agricultural

Data

- Unit-level data from five rounds of National Sample Surveys on Employment and Unemployment Situation in India (NSS EUS). Descriptive statistics

- Climate variables were obtained from the University of East Anglia's Climate Research Unit (CRU)
  - 30 years monthly precipitation and monthly mean temperature

- Weather variables were obtained from the Government of India's National Centre for Medium Range Weather Forecasting (NCMRWF)
  - June-September daily accumulated rainfall
  - June-September daily mean temperature
  - June-September daily relative humidity

Real average day wage trend, Rural All-India

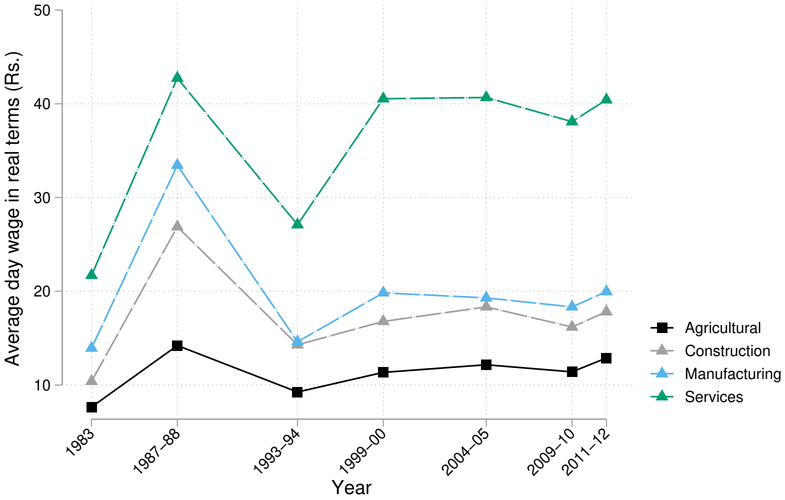


Table Growth Rate

Plot Mean monthly per capita expenditure

Empirical Specification: Wages and Employment

Base specification:

$$ln(y_{dt}) = f(\theta_{dt}) + \alpha_d + \phi_s t + \varepsilon_{dt}$$

y_{dt} represents the outcome of interest in district d in year t;

$f(\theta_{dt})$ is a function of rainfall and temperature;

Z_{dt} represents controls at the district level;

α_d is a vector of district fixed effects;

ϕ_{st} is a vector of state-year fixed effects;

ε_{dt} represents error terms.

Effects of weather on the share of employment by sector at the district level (log): Panel estimates

	Agriculture	Non-agricultural
Degree days (thousands) $(8-32°C)$	-1.438	-1.227
	(1.381)	(1.500)
	[1.159]	[1.252]
Degree days squared	0.473	0.102
	(0.289)	(0.301)
	[0.236]**	[0.256]
Square root of HDD $(34°C)$	0.006	-0.006
	(0.008)	(0.009)
	[0.008]	[0.008]
Monsoon Rainfall$_t$ (Kg/m2, log)	0.091	0.040
	(0.047)*	(0.049)
	[0.043]**	[0.045]
Observations	15,890	24,235
Number of Districts	568	561

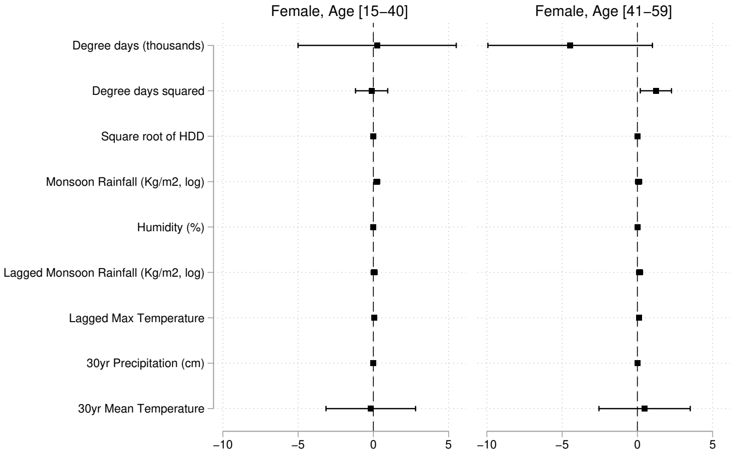
Controls for lagged weather and long-run climatic variables;
District and State-year FEs.

Effects of weather on the average day wage at the district level (Rs., log): Panel estimates

	Agriculture	Non-agricultural
Degree days (thousands) $(8-32°C)$	1.441	1.675
	(1.872)	(1.350)
	[1.749]	[1.022]*
Degree days squared	-0.251	-0.269
	(0.325)	(0.276)
	[0.327]	[0.226]
Square root of HDD $(34°C)$	0.006	0.0002
	(0.008)	(0.009)
	[0.007]	[0.007]
Monsoon Rainfall$_t$ (Kg/m2, log)	0.026	-0.003
	(0.032)	(0.043)
	[0.033]	[0.037]
Observations	5,883	11,045
Number of Districts	428	544

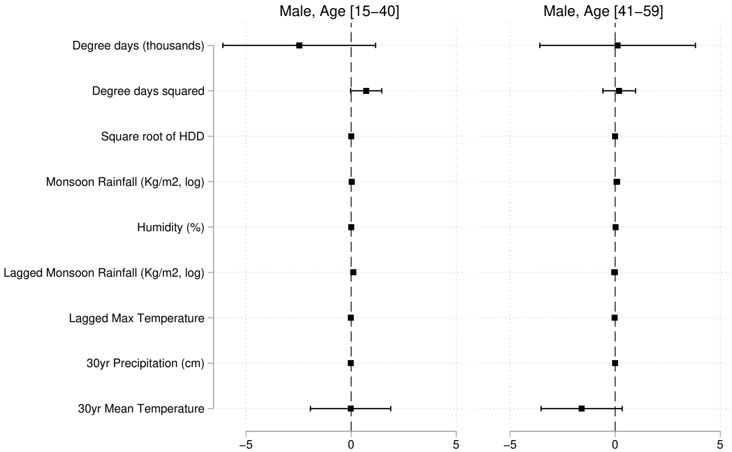
Controls for lagged weather and long-run climatic variables;
District and State-year FEs.

Impact of weather on female share of rural employment in agriculture at the district level (log): Coefplots



Plot Female share of employment in non-agricultural sector

Impact of weather on male share of rural employment in agriculture at the district level (log): Coefplots



Plot Male share of employment in non-agricultural sector

Precipitation variability measures: share of employment in agriculture at the district level (log).

	Rainfall CV	Shannon	Dry 10-day
Degree days$_{1000}$ $(8-32°C)$	-1.438	-1.436	-1.490
	(1.158)	(1.160)	(1.157)
Degree days squared	0.473**	0.472**	0.476**
	(0.236)	(0.237)	(0.236)
Monsoon Rainfall$_t$ (Kg/m2, log)	0.108**	0.095*	0.087*
	(0.050)	(0.055)	(0.045)
Rainfall CV	-0.015		
	(0.021)		
Shannon Diversity		0.035	
		(0.270)	
Dry 10-day			-0.008
			(0.012)
Observations	15,890	15,890	15,890
Number of Districts	568	568	568

Controls for lagged weather and long-run climatic variables;
District and State-year FEs.

Precipitation variability measures: share of employment in non-agricultural sector at the district level (log).

	Rainfall CV	Shannon	Dry 10-day
Degree days$_{1000}$ $(8-32°C)$	-1.190	-1.235	-1.126
	(1.249)	(1.243)	(1.256)
Degree days squared	0.101	0.126	0.096
	(0.255)	(0.254)	(0.256)
Monsoon Rainfall$_t$ (Kg/m2, log)	-0.018	-0.036	0.048
	(0.058)	(0.061)	(0.045)
Rainfall CV	0.051*		
	(0.027)		
Shannon Diversity		-0.646**	
		(0.300)	
Dry days 10			0.014
			(0.013)
Observations	24,235	24,235	24,235
Number of Districts	561	561	561

Controls for lagged weather and long-run climatic variables;
District and State-year FEs.

Robustness check: share of employment at the district level (log).

	Agriculture	Non-agricultural
Degree days (thousands) $(8 - 32°C)$	-1.602	-1.037
	(1.202)	(1.279)
DD x High GWR	-0.133	0.271
	(0.204)	(0.276)
Monsoon Rainfall (Kg/m2, log)	0.100**	0.011
	(0.046)	(0.049)
Rain x High Discharge	-0.026	0.064
	(0.048)	(0.049)
Observations	15,630	23,460

Controls for lagged weather and long-run climatic variables;
District and State-year FEs.

Main Findings:

- Degree days increases the share of the labor in construction sector at the decreasing rate.
- Young and elderly male, and young female allocates labor to the construction sector in response to the rainfall variability.
- Construction sector provides a cushion for casual wage labor impacted due to climatic distress.

Future Directions:

- Using India Human Development Survey repeat the analyses at the individual level.

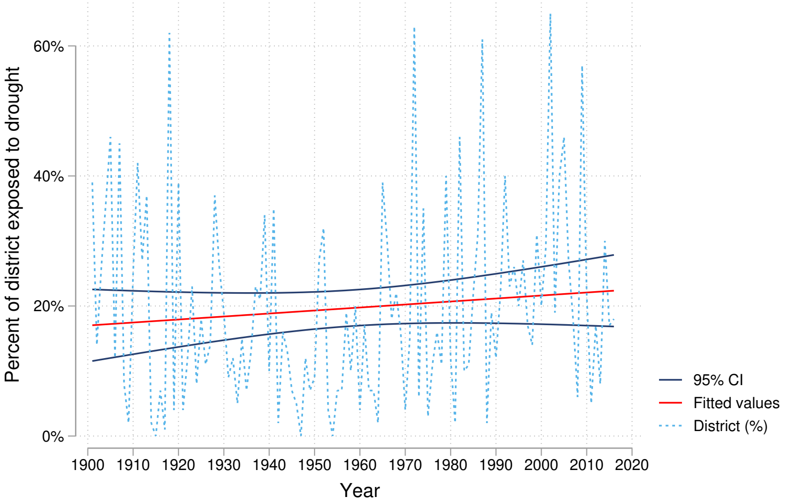


Figure: 1. Incidence of drought (rainfall below 20th percentile of long-run historical average) at the district level (based on 2011 India Census district geographic boundaries) between 1901-2016. (Source: CRU)

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Impact of drought on yields for cereals and pulses

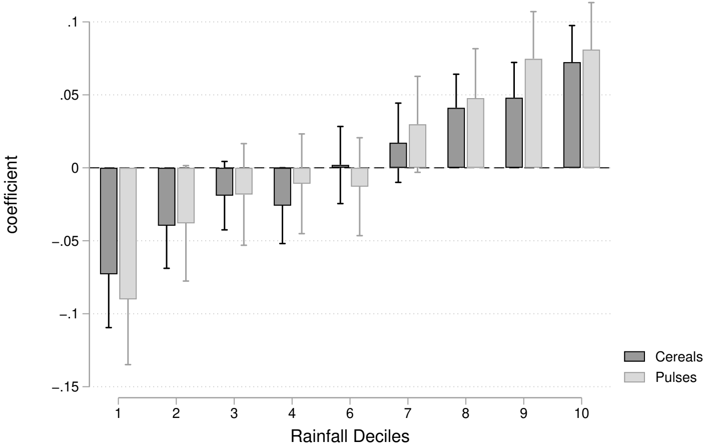

Figure: 2. Coefficient for rainfall deciles and 95% CI in India. The dependent variable is the natural logarithm of annual crop yield (kg per hectare) from 2001 to 2015. The specification include district and year fixed effects. The 5th decile is selected as reference.(Source: ICRISAT)

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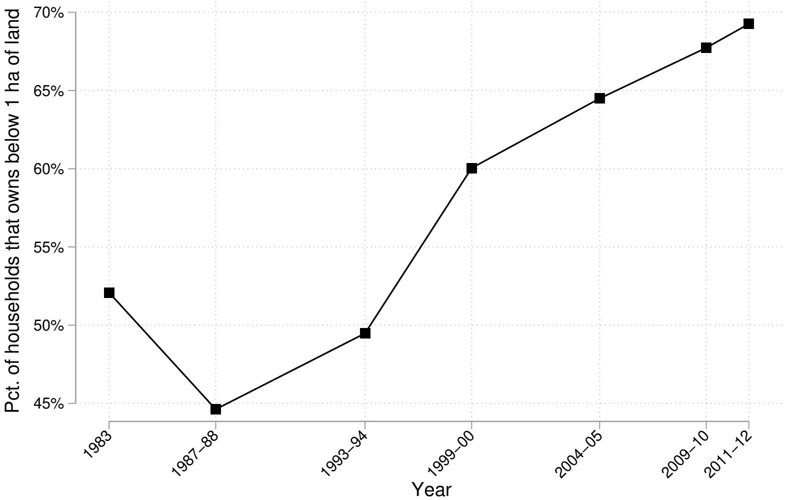

Figure: 3. Percentage of rural households that owns less than 1 hectare of land.
Source: Unit-level data from various rounds of National Sample Survey on Employment and Unemployment Situation (NSS EUS) in India.

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Distribution of average land holdings in rural India.

	Subsistence (Below 1 ha)		Commercial (10 and above ha)	
Year	Pct.(%)	Mean (sd)	Pct.(%)	Mean (sd)
1983	52.08	0.29 (0.30)	1.71	31.75 (180.23)
1987-88	44.62	0.33 (0.30)	9.87	16.48 (09.57)
1993-94	49.48	0.33 (0.30)	8.89	17.30 (29.59)
1999-00	60.05	0.29 (0.30)	1.99	16.03 (10.96)
2004-05	64.49	0.27 (0.30)	4.98	16.79 (70.33)
2009-10	67.73	0.23 (0.28)	4.68	14.97 (07.09)
2011-12	69.26	0.24 (0.28)	4.95	14.36 (05.27)

Source: NSS EUS data.

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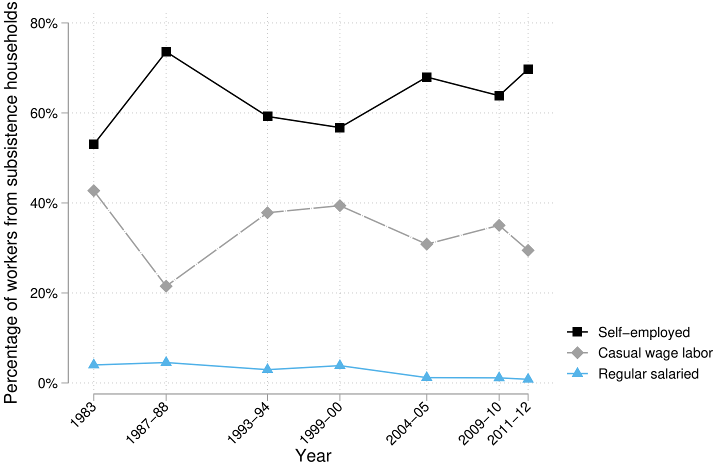
Distribution of types of workers engaged in agricultural sector from subsistence households, Rural All-India



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Real Agricultural Earnings, Rural All-India (Rs., in 1983 Rural Maharashtra Prices)

Year	Daily Earnings (Rs.)	Growth Rate (%)	AGR[a] (%)
1983	7.65	-	-
1987-88	14.22	85.77	17.15
1993-94	9.26	-34.89	-6.98
1999-00	11.35	22.63	4.53
2004-05	12.16	7.16	1.43
2009-10	11.40	-6.24	-1.25
2011-12	12.88	12.97	6.48

a: AGR stands for annualised rates of growth.
Source: NSS EUS data.

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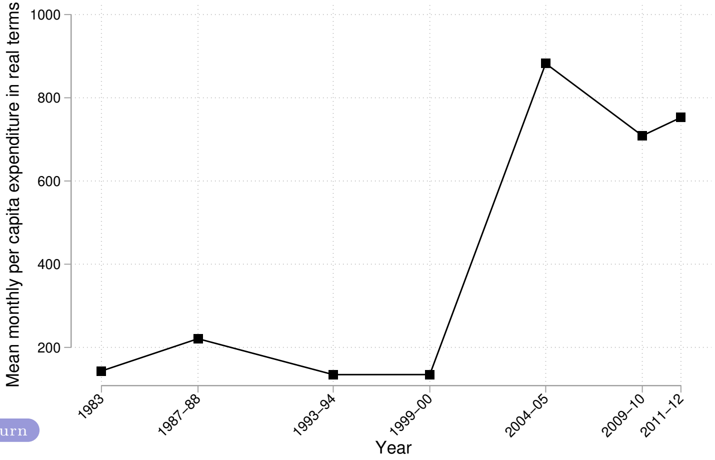
Mean monthly per capita expenditure, Rural All-India (Rs., in 1983 Rural Maharashtra Prices)



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District Level Descriptive Statistics: Local Labor Market in rural India (2004-2011).

	Mean	Std. Dev. (within)	Std. Dev. (between)
Panel A: Wage (Rs.)			
Avg. Day Wage: Agriculture	75.48	40.90	32.65
Avg. Day Wage: Non-agricultural	189.66	113.06	112.74
Panel B: Employment			
Employment Share: Agriculture	0.09	0.03	0.07
Employment Share: Non-agricultural	0.04	0.02	0.03
Unemployment Share of Labor Force	0.05	0.02	0.03
Panel C: Meteorological			
Daily Max. Temperature (°C)	32.15	0.70	3.63
Monsoon Rainfall (Kg/m2)	1253.25	250.81	788.09

Source: NSS EUS data.

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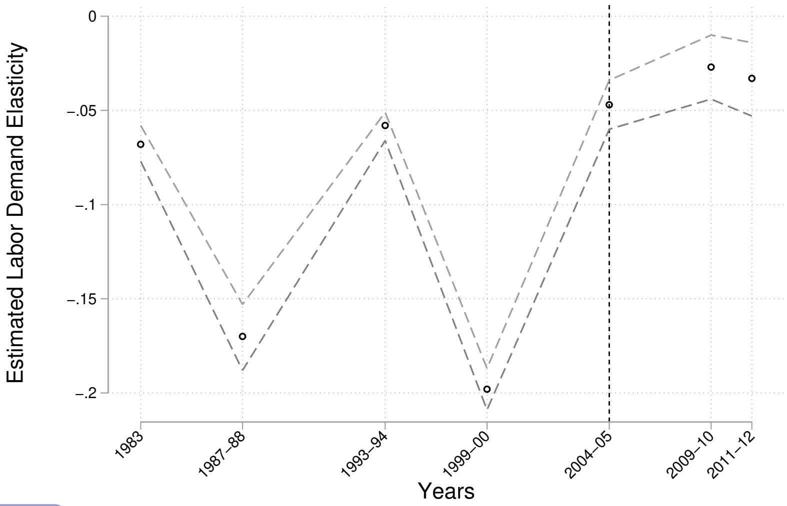
Rural Labor Demand Elasticity for Agriculture: Number of days employed in agriculture in a week.



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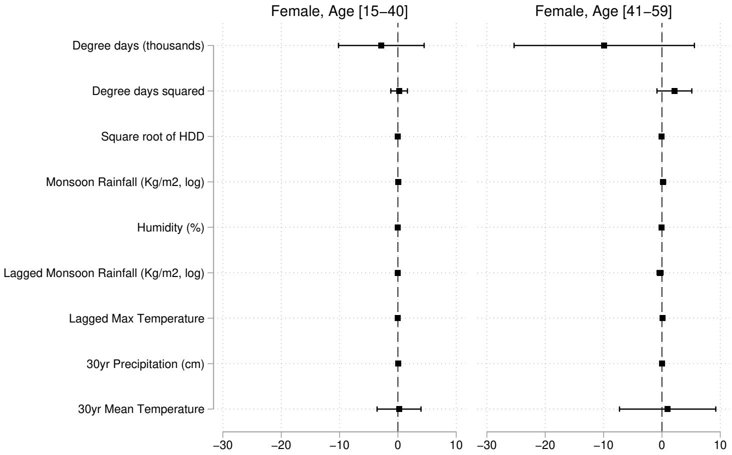
Impact of weather on female share of rural employment in non-agricultural sector at the district level (log): Coefplots



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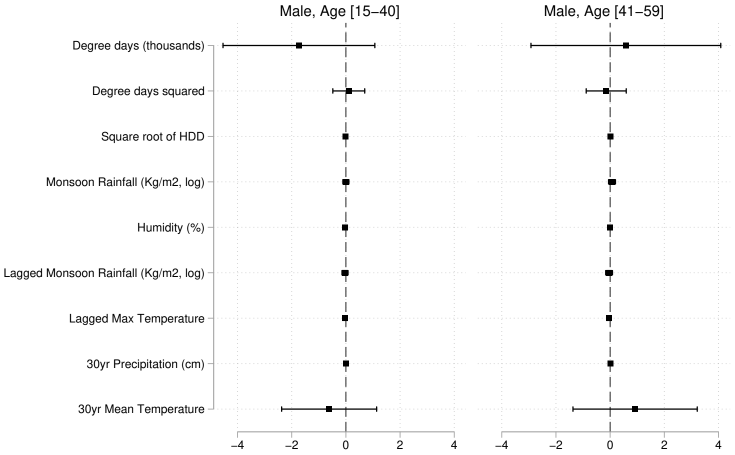
Impact of weather on male share of rural employment in non-agricultural sector at the district level (log): Coefplots



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