Supplement to “Contracting under uncertainty: Groundwater in South India”

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This supplement to “Contracting under uncertainty: groundwater in South India” contains three sections. Section B shows that borewells are less likely to be sunk on small plots, Section C provides evidence on the returns to scale assumption maintained in the theoretical model, and Section D presents additional tables referred to in the main text.

Appendix B: Borewells less likely to be sunk on small plots

Our survey covers 9584 plots, each of which either has a borewell itself or is adjacent to a plot that does, and thus, could in principle receive a transfer of groundwater. Figure B.1 shows that borewells are much less likely on small plots than on large

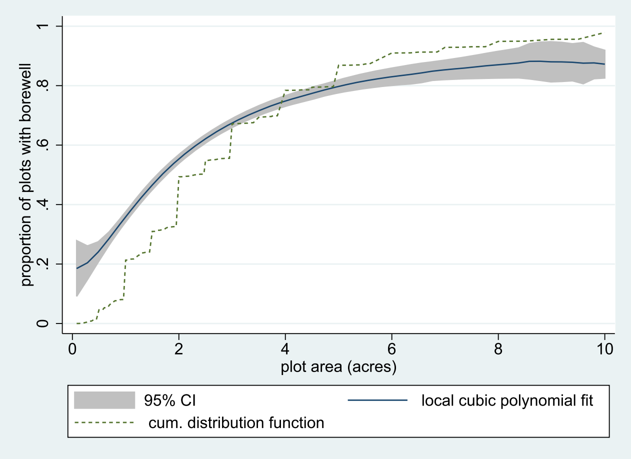

Figure B.1. Presence of a borewell and plot area. *Notes*: Nonparametric regression of borewell indicator on plot area using sample of 9584 plots that either have or are adjacent to a borewell.

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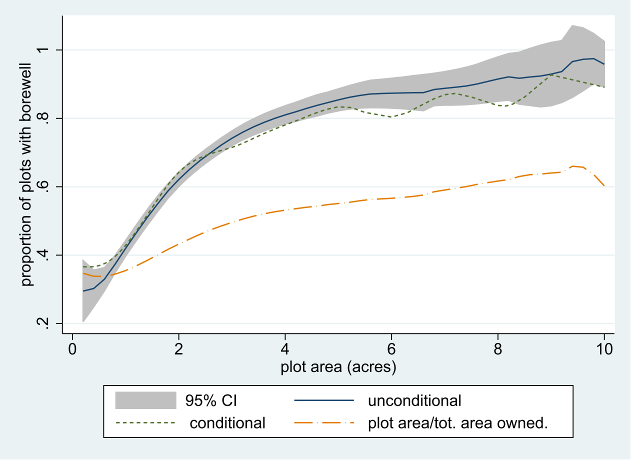

FIGURE B.2. Wealth, presence of a borewell and plot area. *Notes*: Nonparametric regression of borewell indicator on plot area using subsample of 4544 plots whose owners possess at least one other plot. The solid curve replicates that of Figure B.1 on the smaller sample, whereas the short-dashed curve partials out 9 dummies for the deciles of total land area owned.

ones. One might think that a random allocation of borewells across space could generate such a pattern mechanically; larger plots would be more likely to have borewells insofar as they constitute the majority of farmland area. But this ignores the fact that well placement is determined by individual decision-makers at the plot-level. If we suppose, not unreasonably, that the probability of finding a viable groundwater source (i.e., an underground spring) is uniform across space and that each plot-owner makes the same number of drilling *attempts*, then the likelihood of observing a borewell under the null hypothesis should be equal across plots of different size. To be sure, owners of small plots may also be less wealthy, and thus unable to afford multiple drilling attempts, or any attempts at all for that matter. To control for wealth, consider the subsample of 4544 plots whose owners possess at least one other plot (otherwise, plot area and total owned area are perfectly correlated). Partialing out the effect of wealth (as proxied by total landholdings) using dummies for each of the deciles of total landownership, yields Figure B.2, which confirms that borewells *are* more likely on larger plots.

APPENDIX C: ESTIMATES OF THE PRODUCTION FUNCTION

Four years after the Groundwater Markets Survey, we fielded a new survey in three of the original six districts (Anantapur, Guntur, and Kadapa). Designed as the baseline for a RCT of drip irrigation, the 2016 survey, in addition to farmer, plot, and borewell characteristics, collected detailed *rabi* season 2015–2016 production data for a random sample of 990 plots with borewells. Using these data, we estimate a Cobb–Douglas specification

Table C1. Production function estimates.

	(1) OLS	(2) 2SLS	(3) 2SLS	(4) 2SLS	(5) 2SLS
$\log l$ (irrigated area)	–	0.889	0.743	0.812	0.839
		(0.103)	(0.104)	(0.103)	(0.103)
$\log a$ (plot area)	0.793	–	–	–	–
	(0.094)				
$\log w$ (GW supply)	0.275	0.239	0.310	0.295	0.265
	(0.082)	(0.080)	(0.079)	(0.079)	(0.079)
$H_0 : CRS$ (p-value)		0.313	0.671	0.389	0.398
Observations	990	990	990	990	990
R^2	0.077	0.122	0.175	0.209	0.226
District dummies	NO	NO	YES	YES	YES
Plot controls	NO	NO	NO	YES	YES
Farmer controls	NO	NO	NO	NO	YES

Note: Standard errors in parentheses. District dummies for Anantapur, Guntur, and Kadapa. Plot controls: dummies for soil type, color, and degree of salinity. Farmer controls: age, age squared, gender, education level dummies, caste dummies. Dependent variable is log of *rabi* season crop revenue computed using median sales prices reported in the sample. 2SLS estimates in columns (2)–(5) use plot area as an instrument for irrigated area.

of the form

$$\log y_i = \beta_0 + \beta_1 \log l_i + \beta_2 \log w_i + u_i, \tag{C.1}$$

where y_i is *rabi* crop revenue, l_i is irrigated area of plot, and $w_i = R_i^2 \times \mathbf{1}(\text{end of season flow} = s_k)$, for pipewidth R_i and $s_k \in \{1, \frac{3}{4}, \frac{1}{2}, \frac{1}{4}, \frac{1}{10}\}$, is the analogue of the groundwater supply variable in equation (10). The standard test for CRS has $H_0 : \beta_1 + \beta_2 = 1$. Since, as we have seen, the choice of l_i is endogenous, we use plot area a_i as an instrument.

Column (1) of Table C1 reports, for reference, the reduced form regression of log revenue on log plot area and log groundwater supply. Columns (2)–(5) present the production function estimates with successively richer sets of covariates. Despite the precision of our estimates of β_1 and β_2, we cannot reject the CRS hypothesis that these coefficients sum to unity.[1] Next, we ask whether the relationship between log revenues and log groundwater supply is approximately linear by fitting a multivariate fractional polynomial regression to the column (1) specification. Figure C.1 suggests that this more flexible model does not do appreciably better at fitting the production data. This finding combined with our inability to reject CRS supports the choice of equation (10) as the form for the production function.

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[1] This is exactly the test conducted by Bardhan (1973) in one of the seminal studies of returns to scale in Indian agriculture writ large. For a more recent treatment, emphasizing variable economies of scale by farm size, see Foster and Rosenzweig (2017).

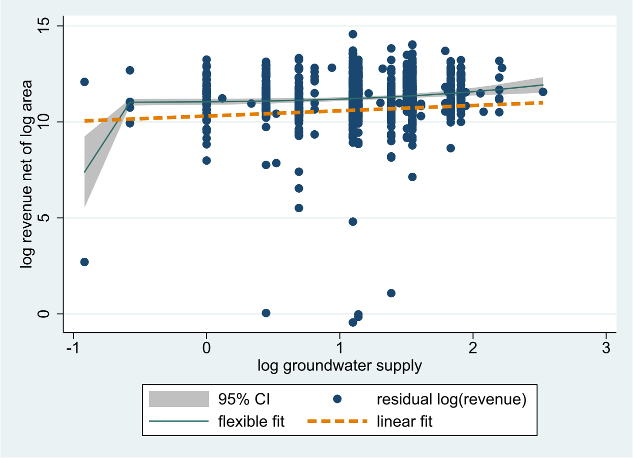

Figure C.1. Flexible versus linear in flow. *Notes*: Solid curve is fit of log revenue to log plot area and log end-of-season flow using multivariate fractional polynomial regression. Dashed line is linear fit of same regression.

Appendix D: Additional tables

See Tables D1, D2, D3 and D4.

Table D1. Logit estimates of contract choice: controlling for crop.

	Full Sample				Estimation Sample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CV (marginal effect)	0.0681	0.0599	0.0614	0.0675	0.0881	0.0764	0.0773	0.0912
	(0.0250)	(0.0250)	(0.0249)	(0.0309)	(0.0322)	(0.0327)	(0.0326)	(0.0356)
Share wet crop	−0.359	−0.331	−0.305	−0.114	−0.359	−0.344	−0.320	−0.165
	(0.0516)	(0.0509)	(0.0511)	(0.0741)	(0.0727)	(0.0714)	(0.0718)	(0.0867)
Pseudo-R^2	0.120	0.139	0.151	0.114	0.0630	0.0819	0.0930	0.0823
Observations	1002	1002	1002	757	737	737	737	646
Controls:								
Borewell	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Reference Plot	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Owner/adjacency	No	No	Yes	Yes	No	No	Yes	Yes
Mandal dummies	No	No	No	Yes	No	No	No	Yes

Note: Standard errors of logit marginal effects in parentheses. Binary dependent variable is one if per-irrigation (spot) contract is chosen and zero otherwise. CV is the coefficient of variation of end-of-season well flow (normalized by the standard deviation of CV in the respective sample). Share wet crop is the fraction of borewell irrigated area under wet (as opposed to ID) crops. Borewell controls: mean end-of-season well flow, mean start-of-season well flow, pump horse-power, log of well depth, dummy for presence of recharge source. Reference plot controls: log plot area, dummies for soil type, color, and degree of salinity. Borewell-owner/adjacency controls: age, education level dummies, forward caste dummy, log total land owned, number of plots in adjacency, log average adjacency plot area. Since logit estimation with *mandal* dummies drops *mandals* without variation in contract type, only 20 *mandals* contribute observations in the full sample and 16 in the estimation sample.

TABLE D2. Logit estimates of groundwater transfer probability.

	Full Sample				Estimation Sample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CV (marginal effect)	−0.193	−0.191	−0.156	−0.0241	−0.157	−0.144	−0.112	0.000504
	(0.0279)	(0.0284)	(0.0281)	(0.0316)	(0.0292)	(0.0301)	(0.0295)	(0.0319)
Pseudo-R^2	0.231	0.241	0.286	0.369	0.165	0.175	0.226	0.319
Observations	2414	2414	2414	2346	1646	1646	1646	1631
Controls:								
Borewell	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Reference Plot	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Owner/adjacency	No	No	Yes	Yes	No	No	Yes	Yes
Mandal dummies	No	No	No	Yes	No	No	No	Yes

Note: Standard errors of logit marginal effects in parentheses. Binary dependent variable is one if a groundwater transfer is made and zero otherwise. CV is the coefficient of variation of end-of-season well flow (normalized by the standard deviation of CV in the respective sample). Borewell controls: mean end-of-season well flow, mean start-of-season well flow, pump horsepower, log of well depth, dummy for presence of recharge source. Reference plot controls: log plot area, dummies for soil type, color, and degree of salinity. Borewell-owner/adjacency controls: age, education level dummies, forward caste dummy, log total land owned, number of plots in adjacency, log average adjacency plot area.

TABLE D3. Choice probability integration limits by configuration.

Configuration	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CAU	$(-\infty, \tilde{\varepsilon}_{CA}]$	$[\tilde{\varepsilon}_{CA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$				
CLAU	$(-\infty, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}_{LA}]$	$[\tilde{\varepsilon}_{LA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$			
CLCAU	$(-\infty, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}^2_{CL}]$	$[\tilde{\varepsilon}^2_{CL}, \tilde{\varepsilon}_{CA}]$	$[\tilde{\varepsilon}_{CA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$		
CLCPAU	$(-\infty, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}^2_{CL}]$	$[\tilde{\varepsilon}^2_{CL}, \tilde{\varepsilon}^1_{CP}]$	$[\tilde{\varepsilon}^1_{CP}, \tilde{\varepsilon}_{PA}]$	$[\tilde{\varepsilon}_{PA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$	
CLCPCAU	$(-\infty, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}^2_{CL}]$	$[\tilde{\varepsilon}^2_{CL}, \tilde{\varepsilon}^1_{CP}]$	$[\tilde{\varepsilon}^1_{CP}, \tilde{\varepsilon}^2_{CP}]$	$[\tilde{\varepsilon}^2_{CP}, \tilde{\varepsilon}_{CA}]$	$[\tilde{\varepsilon}_{CA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$
CLPAU	$(-\infty, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}^1_{PL}]$	$[\tilde{\varepsilon}^1_{PL}, \tilde{\varepsilon}_{PA}]$	$[\tilde{\varepsilon}_{PA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$		
CLPCAU	$(-\infty, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}_{PL}]$	$[\tilde{\varepsilon}_{PL}, \tilde{\varepsilon}^2_{CP}]$	$[\tilde{\varepsilon}^2_{CP}, \tilde{\varepsilon}_{CA}]$	$[\tilde{\varepsilon}_{CA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$	
CLPLAU	$(-\infty, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}^1_{PL}]$	$[\tilde{\varepsilon}^1_{PL}, \tilde{\varepsilon}^2_{PL}]$	$[\tilde{\varepsilon}^2_{PL}, \tilde{\varepsilon}_{LA}]$	$[\tilde{\varepsilon}_{LA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$	
CLPLCAU	$(-\infty, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}^1_{PL}]$	$[\tilde{\varepsilon}^1_{PL}, \tilde{\varepsilon}^2_{PL}]$	$[\tilde{\varepsilon}^2_{PL}, \tilde{\varepsilon}^2_{CL}]$	$[\tilde{\varepsilon}^2_{CL}, \tilde{\varepsilon}_{CA}]$	$[\tilde{\varepsilon}_{CA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$
CPAU	$(-\infty, \tilde{\varepsilon}^1_{CP}]$	$[\tilde{\varepsilon}^1_{CP}, \tilde{\varepsilon}_{PA}]$	$[\tilde{\varepsilon}_{PA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$			
CPCAU	$(-\infty, \tilde{\varepsilon}^1_{CP}]$	$[\tilde{\varepsilon}^1_{CP}, \tilde{\varepsilon}^2_{CP}]$	$[\tilde{\varepsilon}^2_{CP}, \tilde{\varepsilon}_{CA}]$	$[\tilde{\varepsilon}_{CA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$		
CPCLAU	$(-\infty, \tilde{\varepsilon}^1_{CP}]$	$[\tilde{\varepsilon}^1_{CP}, \tilde{\varepsilon}^2_{CP}]$	$[\tilde{\varepsilon}^2_{CP}, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}_{LA}]$	$[\tilde{\varepsilon}_{LA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$	
CPLAU	$(-\infty, \tilde{\varepsilon}^1_{CP}]$	$[\tilde{\varepsilon}^1_{CP}, \tilde{\varepsilon}_{PL}]$	$[\tilde{\varepsilon}_{PL}, \tilde{\varepsilon}_{LA}]$	$[\tilde{\varepsilon}_{LA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$		
CPLAU	$(-\infty, \tilde{\varepsilon}^1_{CP}]$	$[\tilde{\varepsilon}^1_{CP}, \tilde{\varepsilon}^2_{PL}]$	$[\tilde{\varepsilon}^2_{PL}, \tilde{\varepsilon}_{LA}]$	$[\tilde{\varepsilon}_{LA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$		
CPLCAU	$(-\infty, \tilde{\varepsilon}^1_{CP}]$	$[\tilde{\varepsilon}^1_{CP}, \tilde{\varepsilon}_{PL}]$	$[\tilde{\varepsilon}_{PL}, \tilde{\varepsilon}^2_{CL}]$	$[\tilde{\varepsilon}^2_{CL}, \tilde{\varepsilon}_{CA}]$	$[\tilde{\varepsilon}_{CA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$	
LAU	$(-\infty, \tilde{\varepsilon}_{LA}]$	$[\tilde{\varepsilon}_{LA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$				
LCAU	$(-\infty, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}_{CA}]$	$[\tilde{\varepsilon}_{CA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$			
LCLAU	$(-\infty, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}^2_{CL}]$	$[\tilde{\varepsilon}^2_{CL}, \tilde{\varepsilon}_{LA}]$	$[\tilde{\varepsilon}_{LA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$		
LCLPAU	$(-\infty, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}^2_{CL}]$	$[\tilde{\varepsilon}^2_{CL}, \tilde{\varepsilon}_{PL}]$	$[\tilde{\varepsilon}_{PL}, \tilde{\varepsilon}_{PA}]$	$[\tilde{\varepsilon}_{PA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$	
LCPAU	$(-\infty, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}^2_{CP}]$	$[\tilde{\varepsilon}^2_{CP}, \tilde{\varepsilon}_{PA}]$	$[\tilde{\varepsilon}_{PA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$		
LCPCAU	$(-\infty, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}^1_{CP}]$	$[\tilde{\varepsilon}^1_{CP}, \tilde{\varepsilon}^2_{CP}]$	$[\tilde{\varepsilon}^2_{CP}, \tilde{\varepsilon}_{CA}]$	$[\tilde{\varepsilon}_{CA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$	

(*Continues*)

TABLE D3. *Continued.*

Configuration	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LCPLAU	$(-\infty, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}^2_{CP}]$	$[\tilde{\varepsilon}^2_{CP}, \tilde{\varepsilon}^2_{PL}]$	$[\tilde{\varepsilon}^2_{PL}, \tilde{\varepsilon}_{LA}]$	$[\tilde{\varepsilon}_{LA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$	
LPAU	$(-\infty, \tilde{\varepsilon}^1_{PL}]$	$[\tilde{\varepsilon}^1_{PL}, \tilde{\varepsilon}_{PA}]$	$[\tilde{\varepsilon}_{PA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$			
LPCAU	$(-\infty, \tilde{\varepsilon}^1_{PL}]$	$[\tilde{\varepsilon}^1_{PL}, \tilde{\varepsilon}^1_{CP}]$	$[\tilde{\varepsilon}^1_{CP}, \tilde{\varepsilon}_{CA}]$	$[\tilde{\varepsilon}_{CA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$		
LPCLAU	$(-\infty, \tilde{\varepsilon}^1_{PL}]$	$[\tilde{\varepsilon}^1_{PL}, \tilde{\varepsilon}^1_{CP}]$	$[\tilde{\varepsilon}^1_{CP}, \tilde{\varepsilon}^2_{CL}]$	$[\tilde{\varepsilon}^2_{CL}, \tilde{\varepsilon}_{LA}]$	$[\tilde{\varepsilon}_{LA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$	
LPCPAU	$(-\infty, \tilde{\varepsilon}_{PL}]$	$[\tilde{\varepsilon}_{PL}, \tilde{\varepsilon}^1_{CP}]$	$[\tilde{\varepsilon}^1_{CP}, \tilde{\varepsilon}^2_{CP}]$	$[\tilde{\varepsilon}^2_{CP}, \tilde{\varepsilon}_{PA}]$	$[\tilde{\varepsilon}_{PA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$	
LPCPLAU	$(-\infty, \tilde{\varepsilon}^1_{PL}]$	$[\tilde{\varepsilon}^1_{PL}, \tilde{\varepsilon}^1_{CP}]$	$[\tilde{\varepsilon}^1_{CP}, \tilde{\varepsilon}^2_{CP}]$	$[\tilde{\varepsilon}^2_{CP}, \tilde{\varepsilon}^2_{PL}]$	$[\tilde{\varepsilon}^2_{PL}, \tilde{\varepsilon}_{LA}]$	$[\tilde{\varepsilon}_{LA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$
LPLAU	$(-\infty, \tilde{\varepsilon}^1_{PL}]$	$[\tilde{\varepsilon}^1_{PL}, \tilde{\varepsilon}^2_{PL}]$	$[\tilde{\varepsilon}^2_{PL}, \tilde{\varepsilon}_{LA}]$	$[\tilde{\varepsilon}_{LA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$		
LPLCAU	$(-\infty, \tilde{\varepsilon}^1_{PL}]$	$[\tilde{\varepsilon}^1_{PL}, \tilde{\varepsilon}^2_{PL}]$	$[\tilde{\varepsilon}^2_{PL}, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}_{CA}]$	$[\tilde{\varepsilon}_{CA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$	
PAU	$(-\infty, \tilde{\varepsilon}_{PA}]$	$[\tilde{\varepsilon}_{PA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$				
PCAU	$(-\infty, \tilde{\varepsilon}^1_{CP}]$	$[\tilde{\varepsilon}^1_{CP}, \tilde{\varepsilon}_{CA}]$	$[\tilde{\varepsilon}_{CA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$			
PCLAU	$(-\infty, \tilde{\varepsilon}^1_{CP}]$	$[\tilde{\varepsilon}^1_{CP}, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}_{LA}]$	$[\tilde{\varepsilon}_{LA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$		
PCLAU	$(-\infty, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}^1_{CP}]$	$[\tilde{\varepsilon}^1_{CP}, \tilde{\varepsilon}^2_{CL}]$	$[\tilde{\varepsilon}^2_{CL}, \tilde{\varepsilon}_{LA}]$	$[\tilde{\varepsilon}_{LA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$	
PCPAU	$(-\infty, \tilde{\varepsilon}^1_{CP}]$	$[\tilde{\varepsilon}^1_{CP}, \tilde{\varepsilon}^2_{CP}]$	$[\tilde{\varepsilon}^2_{CP}, \tilde{\varepsilon}_{PA}]$	$[\tilde{\varepsilon}_{PA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$		
PCPLAU	$(-\infty, \tilde{\varepsilon}^1_{CP}]$	$[\tilde{\varepsilon}^1_{CP}, \tilde{\varepsilon}^2_{CP}]$	$[\tilde{\varepsilon}^2_{CP}, \tilde{\varepsilon}_{PL}]$	$[\tilde{\varepsilon}_{PL}, \tilde{\varepsilon}_{LA}]$	$[\tilde{\varepsilon}_{LA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$	
PLAU	$(-\infty, \tilde{\varepsilon}_{PL}]$	$[\tilde{\varepsilon}_{PL}, \tilde{\varepsilon}_{LA}]$	$[\tilde{\varepsilon}_{LA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$			
PLCAU	$(-\infty, \tilde{\varepsilon}_{PL}]$	$[\tilde{\varepsilon}_{PL}, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}_{CA}]$	$[\tilde{\varepsilon}_{CA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$		
PLCLAU	$(-\infty, \tilde{\varepsilon}_{PL}]$	$[\tilde{\varepsilon}_{PL}, \tilde{\varepsilon}^1_{CL}]$	$[\tilde{\varepsilon}^1_{CL}, \tilde{\varepsilon}^2_{CL}]$	$[\tilde{\varepsilon}^2_{CL}, \tilde{\varepsilon}_{LA}]$	$[\tilde{\varepsilon}_{LA}, \tilde{\varepsilon}_{AU}]$	$[\tilde{\varepsilon}_{AU}, \infty)$	

Note: See text for definitions of the $\tilde{\varepsilon}_{jj'}$ (i subscript suppressed for convenience). Numerical superscripts refer to cases of a double value function crossing over the range of ε_i, with 1 being the threshold for the leftmost crossing and 2 being the threshold for the rightmost.

TABLE D4. Expanded model predictions.

			Holdout Samples				Anantapur→	
	Est. sample		Anantapur		E. Godavari		E. Godavari	
	Data (1)	Model (2)	Data (3)	Model (4)	Data (5)	Model (6)	$\Delta\pi$ (7)	$\Delta\pi, \Delta R$ (8)
$\Pr(U)$	0.26	0.42	0.51	0.49	0.08	0.26	0.35	0.10
$\Pr(A)$	0.23	0.16	0.47	0.21	0.25	0.10	0.17	0.07
$\Pr(L)$	0.06	0.03	0.01	0.01	0.03	0.16	0.01	0.21
$\Pr(P)$	0.20	0.16	0.01	0.24	0.05	0.19	0.15	0.30
$\Pr(C)$	0.24	0.23	0.00	0.05	0.60	0.30	0.32	0.31
$E \log I$	1.67	1.82	1.06	1.31	2.33	2.63	1.78	2.88

Note: All figures are sample means. Log irrigated area, $\log(I)$, and choice probabilities, $\Pr(j)$, are simulated by drawing 50 values of ε for each borewell and then averaging optimal choices based on parameters of expanded model in Table 7. For out of sample predictions, Anantapur is assigned α_M and c_M (Mahbubnagar parameters) and East Godavari is assigned α_W and c_W (West Godavari parameters) based on agro-climatic similarity. Column (7) reports mean predictions when each borewell in the E. Godavari sample is assigned well-flow state probabilites (π_{ki}) drawn at random from the Anantapur sample. Column (8) is the same as column (7) except that the E. Godavari sample is *also* assigned pipe widths (R_i) drawn at random from the Anantapur sample.

References

Bardhan, P. K. (1973), “Size, productivity, and returns to scale: An analysis of farm-level data in Indian agriculture.” *Journal of Political Economy*, 81 (6), 1370–1386. [3]

Foster, A. D. and M. R. Rosenzweig (2017), “Are there too many farms in the world? Labor-market transaction costs, machine capacities and optimal farm size (no. w23909).” National Bureau of Economic Research. [3]

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