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SUBJECT III
FARM INCOME, PRODUCTIVITY AND METHODOLOGY OF FARM INCOME LEVEL

Constraints in Cotton Cultivation: Cost Issues and Options for Income Increments

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ABSTRACT

The present study attempts to analyse the major changes in cost structure in rainfed and irrigated cotton producing states of India and identify the forces governing changing cost structure for the period 1995-2013. It also attempts to examine the impact of irrigation on cotton yield. It employs 'Panel Fixed Effects Instrumental Variable (IV) Regression' to identify the determinants of cost and 'Inverse Probability Weighted Regression Adjustment (IPWRA)' approach to estimate the impact of irrigation on cotton yield. The results indicate that cost incurred in almost all inputs has risen in both irrigated and rainfed environments during the study period and the extent of increase has been relatively higher in rainfed than the irrigated states. Labour cost has occupied about 10 per cent to 35 per cent of total operational cost across states. The study observes that increasing cost is largely associated with the level of technology adopted. Farm wage has been the next major determinant of cost. Lagged output prices and the rainfall variations have significant but limited influence on cost. Irrigation has a positive impact on cotton yield, ranging from 3-5 quintals/ha.

Keywords: Cotton cultivation, Irrigation, Cotton yield.

JEL: Q1, Q15

I

INTRODUCTION

Risks and uncertainties are inherent part of farming system in India. The weather, yield, price and policy uncertainties cause wide swings in agricultural income and resulting economic distress of agricultural households sometimes gets reflected in the decision to quit farming. It's no wonder when the *Situation Assessment Survey of Farmers* indicated that around one-third of agricultural households mentioned farming as unremunerative enterprise and two-fifth of the agricultural households wish to discontinue farming as a primary occupation (Government of India, 2003). The agriculture sector has been under constant scrutiny in the post-reforms period, following the 'growth deceleration' across states. Phrases like 'technology fatigue', 'policy fatigue', 'institutional fatigue' and 'general neglect of agriculture' are not uncommon in this sector. The other set of symptoms depicting agrarian crisis include rising input costs, dwindling market prices and lack of sources of livelihood to the farmers (Raghavan, 2008). Cash crops like cotton suffer more through these

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uncertainties as expenses incurred in cultivation are relatively higher than the staple crops. Since the introduction of Bt cotton in India (2002-03 onwards), spectacular changes have been observed in cotton cultivation. There has been several studies that establish positive social and economic gains of adopting Bt cotton ranging from poverty reduction and rural development (Subramanian and Qaim, 2010), higher yield and lower pesticide use (Krishna and Qaim, 2012), increase in positive health externalities (Kouser and Qaim, 2011) and others. In Indian context, while studies exist that address either national phenomenon like structural changes in cotton yield and its impact on long-term productivity growth (Srivastava and Kolady, 2016), or that correlates adoption of Bt cotton and farmer suicides (Gutierrez *et al.*, 2015) or that address region specific issues (Narayanamoorthy and Kalamkar, 2006), there exists paucity of research that address the forces that determine increasing costs of cultivation. In this context, the present study attempts to explore the changes in cost structure in cotton cultivation and analyse the forces that determine the changing cost structure among nine[1] major cotton growing states of India during the post-reforms period (1996-2013). Further, while farmers have limited or no control over macroeconomic forces that operate the cost incurred in cultivation, identifying feasible solutions at the farm level that improve yield level where farmers could have their control would help in raising their income. In this context, the present study focussed on the role of irrigation in increasing cotton yield in three major cotton growing states of India.

II

DATA AND METHODOLOGY

2.1. *Changes in Cost Structure in Cotton Cultivation*

The changes in direction in relative shares of variable and fixed costs have important implications on capital formation and income distribution in the agrarian society. Adequate knowledge of the changes in cost structure could help the policy makers in providing suitable incentives to the farmers. The present study attempted to study the changes in cost components in major cotton growing states of the country for the period TE 1994-95 to TE 2012-13. The data were collated from the reports of Cost of Cultivation of Principal Crops in India, the Commission for Agricultural Costs and Prices (CACP). The study focused on nine major cotton growing states of India, viz., Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu, Gujarat, Haryana, Madhya Pradesh, Punjab and Rajasthan. The states of Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu were classified as rainfed states as irrigated area under cotton in these states is relatively low (below all-India average of 35 per cent during 2010-11). The remaining five states were classified as irrigated states where area under irrigation ranged from 50 per cent in Madhya Pradesh to 100 per cent in Punjab and Haryana. Simple tabular analysis was employed to analyse the changes in cost incurred in cultivation. Cost components were analysed by working out the shares of each item of cost in the total cost of cultivation and major changes were measured for the period TE 1994-95 and TE 2012-13.

2.2. *Estimating the Cost Function*

Forces that determine cost structure in cotton cultivation were studied for the post-reform period 1996-2013 in major cotton producing states of India. Cost incurred in cultivation was assumed to be influenced by the level of technology adopted, movement in market prices, risk involved in cultivation, farm-non-farm labour interactions and the purchasing power of the people. The level of technology adoption was measured by the magnitude of yield obtained from a given unit of land. The movement in market prices was represented by farm harvest price received in the previous year. Risk in cultivation was symbolised by rainfall deviation. The labour supply in farming was assumed to be correlated with the ratio of farm and non-farm wages and per capita net state domestic product (NSDP) was used to proxy the purchasing power of the public. Farm harvest prices, farm and non-farm wages[2] and NSDP values were deflated using consumer price indices (CPI-AL, base year=2004-05). Cost and price details were obtained from the Directorate of Economics and Statistics (Ministry of Agriculture and Farmers Welfare (MoAFW), Government of India) and NSDP values were collected from the Ministry of Statistics and Programme Implementation (MoSPI), Government of India. Rainfall values were obtained from the secondary sources and deviations were computed from the mean rainfall estimates of the corresponding states. Wage rates were obtained from Labour Bureau (Ministry of Labour and Employment, Government of India).

Having a panel of nine states for the period 1996-2013, we employed fixed effects model to estimate the cost function. This method offers to control for unobserved heterogeneity arising out of omitted variables that influences the cost that are time invariant such as soil fertility levels. Consider a cost function of the following form

$$C_{it} = \beta X_{it} + \gamma_{it} + \varepsilon_{it} \qquad \text{....(1)}$$

where C is cost per hectare incurred in cultivation and X is the vector of explanatory forces discussed above. But this single equation method fails to observe and incorporate the issue of endogeneity in estimating the above function. Yield obtained per unit of land is endogenous in both theoretical and applied sense that it varies with the level of input use such as seeds and fertilisers and manures, and labour and animal power use. We adopted 'Panel Fixed Effects Instrumental Variable Regression' to solve the system. In presence of endogeneity, equation (1) transforms as

$$C_{it} = \alpha O_{it} + \beta X'_{it} + \gamma_{it} + \varepsilon_{it} \qquad \text{....(2)}$$

where O_i refers yield and is endogenous and X_i' comprises all explanatory forces other than yield mentioned in equation (1). The 'Panel Fixed Effects Instrumental Variable Regression' extends the framework of instrumental variable estimation to the panel data structure. A detailed discussion on panel data estimation with endogenous covariates could be found in Baltagi (2013).

2.2. *Estimating the Impact of Irrigation on Cotton Yield*

The biological reasoning of increased yield due to irrigation is beyond doubt and response of cotton yield to irrigation is not an exception. But there exists complexity in explaining absolute yield differences in irrigated and unirrigated environments as irrigation is not the only factor that differs between plots. There operate other socio-economic factors to influence crop yield levels. While quasi-experimental designs allow for measuring yield differences due to irrigation alone, one could not measure such differences in observational studies - the context at present. To get an insight, assume that Y_i is the observed (cotton) yield level of a given plot. We would denote $Y_i = Y_i^1$ when the plot is irrigated and $Y_i = Y_i^0$ when the 'same' plot is left unirrigated. When both the observations are made under identical conditions, the only difference would be the presence or absence 'irrigation' and hence one would measure the average impact of irrigation by averaging the differences between $Y_i^1$and Y_i^0 across all plots. But since one could not observe yield levels of the same plot in an irrigated and unirrigated state at a given time, the possible solution will be to randomize irrigation. Since the decision of the farmer to irrigate is 'not random', the observed data fail to allow estimating efficacy of irrigation. If one could estimate the yield level of an irrigated cotton field if it would have left unirrigated and the level of yield of an unirrigated field if it would have been irrigated, one could find a solution to this problem. In that case, average effect of irrigation (E_I) will be the mean difference of $Y_i^1$and Y_i^0, which can be formally written as

$$E_I = E\left(Y_i^1 - Y_i^o\right) \qquad \text{....(3)}$$

The average effect of irrigation of the irrigated plots (E_{II}) will be the mean difference of $Y_i^1$and Y_i^0 among the irrigated plots.

There exist methods such as propensity score matching (PSM), regression adjustment (RA), Inverse Probability Weighting (IPW) and others in literature to obtain these estimates. We use Inverse Probability Weighted Regression Adjustment (IPWRA)[3] method for this purpose. This method combines the characteristics of both RA and IPW methods in estimating the impact of treatment level on outcome. The method uses two different models, one to predict the treatment status, that is whether a field is irrigated on not, and uses another model to predict outcome, which is 'cotton yield'.[4] Moreover, the estimators obtained have double-robust property and requires only one of the two models to be correctly specified for the estimator to be consistent. To estimate the impact of irrigation on cotton yield, we used the details of plot level data provided by the Directorate of Economic and Statistics (Ministry of Agriculture and Farmers Welfare, Government of India). The data pertained to the year 2011-12.

2.2.1. *Model Specification*

The models specified in IPWRA estimation are shown below. The outcome model is shown in equation (4) and the treatment model is shown in equation (5). In the outcome model, yield was specified as a function of human labour used, machine and animal labour spent and seeds and fertilisers consumed in cultivation. Labour use was measured as the number of labour hours spent in cotton cultivation, and was calculated as the sum of labour hours spent by the farmer itself, the casual and attached labours. Similarly, machine and animal use in cultivation were represented by number of hours of use and were calculated as the sum of own and hired animal and machine hours. Seeds and fertilisers were represented in physical units.

Outcome model: Yield = f {Labour, Animal, Machine, Seed, Fertilizer} ....(4)

Treatment model: Irrigation = f {Area cultivated, Farm wage, Family labour use, Price} ....(5)

In the treatment model, choice of farmers to irrigate the field or not was indicated by a dummy variable – ‘Irrigation’. The variable ‘Irrigation’ obtains the value of ‘1’ when the field was irrigated, and an unirrigated field scores ‘0’. The decision to irrigate or not was explained by total area under cultivation, prevailing farm wage rate, share of family labour in total labours spent and the price of cotton in the market. The size of area under cultivation was expected to be inversely correlated with the irrigation status. That is, higher the field size under crop, lesser the probability of being irrigated. Similarly, farm wage rate was also expected to correlate inversely with the choice of irrigating the field. Increasing demand for farm labour, higher market wages rates and relative costs involved in hiring labour for irrigation are the factors behind such assumption. Conversely, the share of family labour in total labour and market prices was expected to increase the scope of the crop being irrigated. While the former factor would help in reducing costs incurred in cultivation, the latter would help in risking the enterprise for profit gains.[5]

III

RESULTS AND DISCUSSION

3.1. *Cost Structure in Cotton Cultivation*

As mentioned earlier, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu were classified as rainfed states and Gujarat, Punjab, Haryana, Rajasthan and Madhya

Pradesh as irrigated states. The results showed that that during TE 1994-95 and 2012-13, the total cost per hectare has increased from Rs.8,470 to Rs.31,249 in Maharashtra, Rs.14,072 to Rs.32,184 in Andhra Pradesh, Rs.15,368 to Rs. 35,641 in Tamil Nadu, and Rs.12,475 to Rs.20,868 in Karnataka, depicting around 4 times increase in Maharashtra, 2.3 times increase in Andhra Pradesh and Tamil Nadu and a 1.7 times increase in Karnataka respectively during the span of 19 years (Table 1). The increase has occurred almost in all major items of cost. Around 20-30 per cent of increase in total cost was accounted by hired labour alone. This can in partly be attributed to the picking of cotton as this is the most time bound and labor consuming activity. Moreover, imputed value of family labour accounted for about 35 per cent of increase in total cost in Tamil Nadu. Other inputs have also been part of the increase in cost, especially the chemicals and fertilisers. Out of the total cost, operational cost constituted by more than 70 per cent in Tamil Nadu and Maharashtra, and more than 60 per cent Andhra Pradesh and Karnataka respectively.

The pattern of change had been similar in irrigated states as in rainfed states and it was only the extent of change that differed (Table 2). In case of irrigated states, increase in cost was highest in Madhya Pradesh and Gujarat, i.e., Rs.14,653/- and Rs. 12,627/- respectively. In rest of the states, it varied between 1.44 to 1.75 times. The share of hired labour in increase in total cost ranged from 9 per cent in Madhya Pradesh to the highest of 34 per cent in Punjab. The other feature one could find is that the shares of operational costs were relatively higher in irrigated than the rainfed states and labour cost accounted for major share in both rainfed and irrigated states. In general, it could be said that the labour cost forms sizeable share of total cost involved in cotton cultivation and increase in labour cost could be due to the changes in wage rates. The positive changes in seed cost could be attributed to the large increase in prices of seeds as seed rates have declined across states. Similarly, the change in fertiliser cost could be due to increase in input use and prices over years.

3.2. *Factors behind Increasing Cost*

We focussed an issue of rising cost and studied the forces determining increasing cost in cotton cultivation using 'Panel Fixed Effects Instrumental Variable (IV) Regression' approach. The results[6] obtained are presented in Table 3. Turning our focus on the model and variables selected for the purpose, the F statistic (28.80) and corresponding probability value (0.00) indicated fitness of the model and confirmed the fact that not all the coefficients are different from zero. The R-square value showed that more than 63 per cent of variance in cost is explained by the covariates chosen. The sign and significance of the coefficients of cost determinants showed that except income per capita of the public, all other variables have significant influence on cost. While the yield level and lagged market price of cotton were found to be positively associated with increasing cost over time, farm-nonfarm wage ratio and rainfall deviation were found to reduce the cost incurred in cotton cultivation.

TABLE 1. COST STRUCTURE AND CHANGES IN COST OF CULTIVATION OF COTTON IN RAINFED STATES: 1994-95 AND 2012-13

(*Rs./ha*)

Particulars	Maharashtra			Andhra Pradesh			Tamil Nadu			Karnataka		
	1994-95	2012-13	Per cent change	1994-95	2012-13	Per cent change	1994-95	2012-13	Per cent change	1994-95	2012-13	Per cent change
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A. Operational costs												
Family labour	666.7	3823.4	473.5	1056.2	3031.2	187.0	2218.5	9292.4	318.9	1303.7	2050.5	57.3
Hired human labour	1437.3	6635.0	361.6	2284.7	7535.7	229.8	3242.0	8248.2	154.4	1705.8	4369.6	156.2
Bullock labour	1103.0	3335.2	202.4	783.5	1178.4	50.4	500.0	152.9	-69.4	1778.3	1232.2	-30.7
Machine labour	115.8	1263.7	991.4	151.3	1399.3	824.7	280.8	2107.4	650.6	382.5	1311.1	242.8
Seed	478.9	1718.8	258.9	535.9	1766.7	229.6	325.2	1296.4	298.7	775.9	1854.6	139.0
Fertilizer	768.6	2652.7	245.2	1180.8	2782.0	135.6	1248.6	3203.5	156.6	1059.0	1509.5	42.5
Farm yard manure	374.9	912.5	143.4	164.2	661.4	302.7	161.2	834.1	417.4	470.4	415.0	-11.8
Insecticides	435.0	1073.3	146.8	1202.7	1350.2	12.3	642.3	907.6	41.3	658.3	437.1	-33.6
Irrigation charges	87.9	806.7	817.2	554.5	112.8	-79.7	875.1	523.3	-40.2	117.8	122.9	4.3
Interest on working capital	150.0	575.7	283.7	214.4	524.9	144.8	227.5	539.8	137.3	158.3	112.7	-28.8
Sub-total	5618.1	22797.1	305.8	8128.4	20342.5	150.3	9721.3	27015.8	178.8	8409.9	13415.3	59.5
B. Fixed costs												
Rental value of owned land	1945.6	5520.9	183.8	4779.1	9903.1	107.2	3989.4	6559.4	64.4	2976.6	6325.4	112.5
Rent paid for leased-in land	3.4	17.9	428.2	152.1	332.4	118.5	1.4	21.6	1475.1	0.0	0.0	0.0
Interest on fixed capital	653.5	2506.3	283.6	841.7	1415.3	68.1	1436.9	1755.7	22.2	868.6	958.9	10.4
Sub-total	2852.1	8451.9	196.3	5943.7	11841.8	99.2	5646.2	8535.4	51.2	4065.0	7452.4	83.3
Total cost (A+B)	8470.2	31249.0	268.9	14072.1	32184.2	128.7	15367.5	35641.2	131.9	12474.9	20867.8	67.3

Note: Sub-total of fixed cost include cost items of land revenue and depreciation on implements and buildings as well.

TABLE 2. COST STRUCTURE AND CHANGES IN COST OF CULTIVATION OF COTTON IN IRRIGATED STATES: 1994-95 AND 2012-13

	Gujarat			Punjab			Haryana			Rajasthan			Madhya Pradesh		
Particulars	1994-95	2012-13	Per cent change	1994-95	2012-13	Per cent change	1994-95	2012-13	Per cent change	1994-95	2012-13	Per cent change	1994-95	2012-13	Per cent change
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
A. Operational costs															
Family labour	1882.5	4602.2	144.5	2875.2	2875.6	0.0	4566.0	7148.4	56.6	3940.3	8383.9	112.8	616.9	3425.3	455.2
Hired human labour	3688.0	5591.0	51.6	3017.5	6542.8	116.8	1539.5	3549.3	130.5	652.9	1822.2	179.1	757.8	2109.1	178.3
Bullock labour	1541.6	1238.6	-19.7	170.2	130.4	-23.4	778.3	551.6	-29.1	1409.3	198.5	-85.9	517.5	1296.8	150.6
Machine labour	460.6	1555.1	237.6	1058.8	2115.7	94.8	630.8	1584.9	151.3	435.2	1012.3	132.6	63.6	603.3	848.0
Seed	649.5	1631.1	151.1	416.5	2765.7	564.1	355.3	707.4	99.1	399.5	1855.2	364.3	318.3	1164.2	265.8
Fertilizer	1407.4	1702.3	21.0	1248.7	1707.8	36.8	1035.0	1173.1	13.3	719.6	1128.7	56.9	545.3	994.4	82.4
Farm yard manure	494.9	1360.9	175.0	18.6	6.9	-63.1	0.0	7.8	0.0	374.0	547.8	46.5	386.6	345.4	-10.7
Insecticides	1196.0	1340.1	12.0	2924.2	2433.4	-16.8	1438.2	850.7	-40.8	1217.0	1078.5	-11.4	265.6	890.3	235.2
Irrigation charges	1494.7	1607.9	7.6	400.4	207.8	-48.1	396.1	1509.3	281.0	296.8	453.2	52.7	160.2	201.1	25.5
Interest on working capital	290.4	500.5	72.3	290.1	497.0	71.3	175.2	18.7	-89.3	164.7	253.1	53.7	91.1	237.6	160.8
Sub-total	13105.5	21129.6	61.2	12447.0	19282.9	54.9	10914.3	17101.1	56.7	9609.3	16733.5	74.1	3723.0	11267.5	202.6
B. Fixed costs															
Rental value of owned land	3882.8	7124.8	83.5	7891.5	12450.7	57.8	5310.6	9476.5	78.4	3881.2	8106.4	108.9	1853.5	8449.3	355.9
Rent paid for leased-in land	19.0	372.1	1863.1	1809.9	821.0	-54.6	23.4	0.0	-100.0	83.0	4.4	-94.7	0.0	0.0	0.0
Interest on fixed capital	908.0	1965.4	116.4	1342.5	1497.5	11.5	626.7	1510.1	141.0	1312.0	1337.8	2.0	480.2	850.1	77.0
Sub-total	5043.7	9646.9	91.3	11371.9	14977.1	31.7	6171.4	11142.2	80.5	5449.4	9594.4	76.1	2526.8	9634.7	281.3
Total cost (A+B)	18149.3	30776.4	69.6	23819.0	34260.0	43.8	17085.7	28243.3	65.3	15058.7	26327.9	74.8	6249.8	20902.3	234.4

Note: Sub-total of fixed cost include cost items of land revenue and depreciation on implements and buildings as well.

TABLE 3. DETERMINANTS OF COST IN COTTON CULTIVATION (1996-2013)

Fixed-effects (within) IV regression Group variable : State		Number of observations : 162 Number of groups : 9		
R square : within = 0.632 between = 0.520 overall = 0.552		Observations per group: Min. = 18 Max. = 18 Avg. = 18		
Corr (u_i, Xb) = 0.128		Wald chi-square (5) = 9770.270 Prob > chi-square = 0.000		
Cost	Coefficient	Std. Error	95 per cent Confidence Interval	
(1)	(2)	(3)	(4)	
Yield	1206.171***	104.913	1000.544	1411.797
Farm-nonfarm wage ratio	-11084.890**	4726.078	-20347.84	-1821.952
Farm price_L1	1.060**	0.481	0.117	2.003
Rainfall deviation	-1.921*	1.152	-4.180	0.338
NSDP Percapita	0.044	0.048	-0.049	0.138
Constant	11334.530***	1953.780	7505.194	15163.870
Sigma_u	4277.447			
Sigma_e	3061.605			
Rho	0.661			
F test that all u_i = 0:	F(8, 148) = 28.80	Prob > F : 0.000		
Instrumented : Yield				
Instruments : Farm-nonfarm wage ratio, Farm price_L1, Rainfall deviation, NSDP Per capita, Seed, Fertiliser, Manure, Labour, Animal				

Note: ***, ** and* refer significance at 1 per cent, 5 per cent and 10 per cent levels respectively.

The results indicated that for each quintal of incremental cotton yield, cost has increased for about Rs.1200/-. Increasing real wages in farm sector has reduced the cost spent on labour. Despite of a general belief that increasing farm wages would increase the cost in cultivation, the coefficients obtained indicated that for each unit increase in the farm-nonfarm wage ratio, cost has decreased by around Rs.11000/-. In other words, for each 1 per cent increase in farm wages with respect to nonfarm wages, cost has reduced by Rs.110/-. The reduction in cost observed may be due withdrawal of labour which would have been employed otherwise. Increasing wage rate along with increasing input costs might in part have forced to withdraw part of the labour hiring. The resulting cost differentials would have established a negative relation between wage ratio and cost.

Price incentives and production risk had an influence on cost structure, though their effect was smaller. Higher price realisation for a commodity produced in general induces the farmer to invest more in farming. Accordingly, farm harvest price received at the previous year was used to capture the role of lagged prices on cost spent. As expected, the variable had a positive impact on cost spent, saying that higher the price received in the previous year, higher is the cost invested in cultivation in the following year. Rainfall deviation, which was used as a proxy to measure the risk in cultivation, had a negative impact on cost incurred. Higher rainfall variability raises the risk in investing in farming, represented by the negative coefficient of the corresponding variable.

3.3. *Impact of Irrigation on Cotton Yield*

Farmers have limited or no control over many of the macroeconomic forces used to understand the increasing cost structure in the above analysis. At the farm level, they have control over input use and adopting the technologies available, but not over the prices at which they are offered and the resulting product is purchased back in the market. With an increasing input and output prices, increasing area under irrigation can help in generating higher profits. In this front, impact of irrigation on cotton yield was studied in three major cotton producing states of India[7] and the results are summarised below (Table 4).

TABLE 4. IMPACT OF IRRIGATION ON COTTON YIELD IN SELECTED STATES (2011-12)

Treatment-effects estimation Estimator : IPW regression adjustment Outcome model : Linear Treatment model : Logit		Number of observations All states* = 1273 Gujarat = 643 Maharashtra = 458 Andhra Pradesh = 172	
	Coefficients		
Yield	Andhra Pradesh	Gujarat	Maharashtra
(1)	(2)	(3)	(4)
ATET			
Irrigated field, (1 vs 0)	3.085**	5.339***	3.793***
POM			
Irrigated field, (0)	16.454***	14.920***	15.618***
OME 0			
Labour	0.016***	0.010***	0.006***
Animal	-0.012	-0.054***	-0.019**
Machine	-0.007	-0.005	0.219***
Seed	-0.970***	0.099	-0.462**
Fertiliser	-0.032***	0.020***	0.005**
Constant	14.703***	-0.034	7.136***
OME 1			
Labour	0.012**	0.009***	0.012***
Animal	0.031	-0.046***	-0.034***
Machine	0.120	-0.011	0.069**
Seed	0.072	-1.636***	-1.318**
Fertiliser	0.034***	0.010***	0.009***
Constant	0.180	10.833***	8.543***
TME 1			
Area cultivated	0.646**	-0.246***	-0.253*
Farm wage	0.006	0.006*	0.002
Share of family labour	0.023**	-0.011**	-0.009**
Price of cotton	-0.001	0.002***	0.001
Constant	-1.210	-7.388**	-1.425

Note: a) ATET = Average Treatment Effect of the Treated; OME 0 & OME 1 = Outcome models in different treatment levels; TME = Treatment model; b) ***, ** and* refer significance at 1 per cent, 5 per cent and 10 per cent levels respectively.

One would notice that impact of irrigation varies across states. The average effect of irrigation, measured by ATET, varied from 3 quintals/ha in Andhra Pradesh to 5.3 quintals/ha in Gujarat. The impact had been highest in Gujarat (5.34 quintals/ha), followed by Maharashtra (3.79 quintals/ha) and Andhra Pradesh (3.08 quintals/ha). Focussing on the variables that were assumed to affect yield, one would find that most of the variables influence yield levels significantly. All the variables were found significant in outcome model in Maharashtra. Human labour, machine labour and fertiliser use positively influenced yield levels and animal labour and seed use had negative yield effects. In case of Gujarat, the treatment model had all the variables significant. While area cultivated and share of family labour in total labour were inversely related with the irrigation status, farm wages and cotton prices had positive impact. While many of the variables were found significant, Andhra Pradesh had neither the outcome model, nor the treatment model with high significance among variables.

The observations from the above indicate that irrigation has sizeable impact on increasing yield levels in cotton but the magnitude varies with regions. This could due to the regional differences in crop response to different inputs in irrigated and unirrigated environments. One could observe that factors that govern farmers to determine whether a field should be irrigated or not act in a similar fashion in Gujarat and Maharashtra. For example, while the farmers in Gujarat and Maharashtra are less likely to irrigate when the size of area under cultivation is larger, likelihood of irrigation increased in Andhra Pradesh with an increasing area. Similarly, while the share of family labour reduces the probability of the land in Gujarat and Maharashtra being irrigated, it increases the probability in Andhra Pradesh. And response of irrigation to farm wages and prices are significant in Gujarat but not in rest of the states.

IV

CONCLUSIONS

The present study attempted to explore the major changes in cost structure in cotton cultivation since the post-reform period. Results indicated that expenses incurred in almost all inputs have risen in both irrigated and rainfed environments. The extent of increase in cost in rainfed states between 1995 and 2013 was around 4 times in Maharashtra, 2.3 times in Andhra Pradesh and Tamil Nadu and 1.7 times in Karnataka. Among irrigated states, maximum increase was observed in Madhya Pradesh and Gujarat. The shares of operational costs are relatively higher in rainfed states than the irrigated states and labour cost occupied around 10-35 per cent of total operational costs across states. Animal labour use has generally declined. While seed rate has declined following the introduction of Bt hybrids, seed cost has risen sharply. One could conclude that despite of increase in total returns across states, profits have not risen, especially because of concurrent increase in cost structure.

The study found that increasing cost is associated with the level of technology adoption. It short, higher the yield levels, higher are the costs incurred. Farm wages were found to be the next major determinant of cost. They are found to be inversely correlated with the cost structure and the observed reduction in cost could be due to the reduction in labour employed. Lagged output prices and the rainfall variations had significant but limited influence on costs. While the farmers have limited control over many of the variables that affect the cost, one way to increase income is through irrigation. The results indicated that irrigation has a positive impact on yield, and the absolute yield differences ranged from 3-5 quintals/ha. The observed yield differentials could in part be attributed to the regional differences in crop response to a set of factors. While higher area under cultivation had a positive probability of being irrigated, reverse trends were found in Gujarat and Maharashtra. Similarly, while the likelihood of being irrigated was positive in Andhra Pradesh with an increasing share of family labour in total labour, Gujarat and Maharashtra had negative trends. Despite all, attempts to increase the area under irrigation would help in rising income to the cotton farmers.

NOTES

1. The states are listed in next section.
2. Non-farm wages were deflated by CPI(IW), base year=2004-05.
3. This section provides non-technical discussion on IPWRA method. For derivation, refer Wooldridge (2007) and for detailed technical discussion, refer Wooldridge (2010).
4. This allows one to include relevant variables in two different models. For example, in present case, there are variables that determine whether a farmer irrigates or not but doesn't directly influence yield level. The propensity score method (PSM) doesn't allow to model these variables, whereas the IPWRA method allow to use those variables by allowing to specify separate equations.
5. The 'lagged price' variable would better indicate the decision of the farmer to irrigate the field. Still, because of complexities involved in tracing lagged price in the plot level data, it was decided to use the present price level.
6. The results of first stage estimation are not displayed.
7. We studied Andhra Pradesh, Gujarat and Maharashtra.

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