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COTTON ACREAGE RESPONSE TO PRICE IN TAMIL NADU – A FUNCTIONAL ANALYSIS

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ABSTRACT

Econometric model to study acreage response is of great importance in agricultural planning, more so, when it involves manipulation of price structure. Acreage response to price is conditioned by several factors like soil type, rainfall, irrigation, technical constraints such as crop rotational requirements etc., which affect acreage allocation among crops.

The study endeavours to evaluate supply response for farm sector in case of cotton and the evidence examined covers a period of 44 years (1971-72 to 2014 -15) in the state of Tamil Nadu. For the time series analysis, the period of study is (1971-72 to 2014-15) divided into two; pre-reform period pertaining to 1971-72 to 1989-90; post-reform period covering 1990-91 to 2014-15.

Multiple regression analysis is used through Nerlove's adjustment lag model and traditional model for eight price specifications to test the hypothesis that acreage responds to price and non-price movements positively. The main finding that could emerge from this study is that the acreage responds positively to price changes and it is very much influenced by non-price factors. The eight price specifications seldom give identical results with respect to farmers' acreage decisions.

The study results reveal that P_3 price is the most relevant price at the tn state level in explaining farmer's decisions. In the Tamil Nadu State, as a whole, though the farmers take 2 to 6 years to fully adjust the acreage to change in its price, it is quite clear from the study that price behaviour is at best a decisive factor for area allocation for cotton in Tamil Nadu state in conjunction with factors like rainfall, prices of the competing crops, yield and past acreage. The regression co-efficient (¥) reveals that a high value of coefficient of adjustment indicates lesser rigidity in adjustment of output.

It is concluded that the importance of price is unquestionable from the view point of stability or the increase in cotton acreage. Price then plays an important role in acreage allocation decisions of the farmers.

KEYWORDS: *agricultural planning, cotton, rainfall, agriculture, cash crop*

INTRODUCTION

Econometric model to study acreage response is of great importance in agricultural planning, more so, when it involves manipulation of price structure. Acreage response to price is conditioned by several factors like soil type, rainfall, irrigation, technical constraints such as crop rotational requirements etc., which affect acreage allocation among crops. These factors differ considerably from region to region. Therefore, acreage response is also expected to vary among regions. This fact has prompted to examine the

acreage response to relative prices for cotton in Tamil Nadu state as a whole for the pre reform and post reform periods.

Cotton as a commercial crop plays an important role in transforming subsistence agriculture into a profit oriented business. India has the distinct pride of having the largest cotton growing area namely one- fourth of the World's cotton area and the largest producer of extra-long staple cotton. Cotton is one of the important cash crops grown in many states over an area of about 9.14 million hectares in India. Among the states Tamil Nadu, Gujarat, Punjab and Andhra Pradesh registered the highest yield of cotton in India. Recently cotton is cultivated in an area of 1.29 lakh hectares of land and producing about 5 lakh bales of 170 Kgs / bale in Tamil Nadu. The state registered a productivity growth of 388 Kg / hectare in 2015-16. In view of predominant position occupied by cotton, the cash crop in Tamil Nadu, the response of acreage to price variation becomes significant.

The study endeavours to evaluate supply response for farm sector in case of cotton and the evidence examined covers a period of 44 years (1971-72 to 2014 -15) in the state of Tamil Nadu. For the time series analysis, the period of study is (1971-72 to 2014-15) divided into two; pre-reform period pertaining to 1971-72 to 1989-90; post-reform period covering 1990-91 to 2014-15.

METHODOLOGY AND ANALYSIS

The study attempts to answer the following questions.

1. What are the suitable models to describe acreage response?
2. Whether the Nerlovian adjustment lag model proves to be better than the traditional model?
3. Which of the following price specifications could be said to be more relevant to the farmers' expectations behaviour with respect to their resource allocation?

a) Twelve - month annual average price in previous year ($p_{1)}$.
b) Three - month post-harvest average price in previous year (p_2).
c) Three - month pre-sowing average price in current year ($p_{3)}$.
d) Average of previous year's post-harvest and current year's pre-sowing prices ($p-_{4)}$
e) Three - year average of twelve - month annual average price ($p_{5)}$.
f) Three - year average of three - month post-harvest average price (P_6) .
g) Three - year average of three - month pre-sowing average price ($p_{7)}$.
h) Three-year average of three - month post-harvest and three month pre-sowing average prices (p_8).

4. What are the magnitudes of long run and short run elasticities with respect to relative price changes, yield, rainfall and substitute crop acreage?
5. What is the period taken by farmers to fully adjust to acreage to a change in its price?

Multiple regression analysis is used through Nerlove's adjustment lag model and traditional model to test the hypothesis that acreage responds to price and non-price movements positively. The study covers pre reform period and post reform period for which continuous time series data have been made available from the various issues of Government of Tamil Nadu.

The estimating model included prices, lagged acreage, yield, rainfall, time trend and substitute crop acreage as independent variables with acreage considered as a dependent variable. The effect of the above six independent variables on cotton acreage in Tamil Nadu has been examined because it is not only the price but the quantum of other variables which are important for acreage allocation of cotton.

The results and interpretations of the functional analysis are based on two models, the adjustment lag model and the traditional model to obtain the response relation. Non-linear (logarithmic) regression equations have been fitted to the absolute values of the variables. The logarithmic functions gave consistently better fit and therefore for the study area, they were selected for discussion in this paper.

For the study of Tamil Nadu, a set of sixteen equations are presented. The first eight relate to the adjustment lag model using the first four price specifications with and without a trend value. The remaining eight are the equations based on the traditional model. In the traditional model with no recognition to past acreage, the first four prices are the same as used in the adjustment lag equations and the last four involve three-year average price specifications. On the basis of these sixteen functions the best price expectation has been chosen for subsequent discussion.

RESULTS AND DISCUSSION

As a preliminary analysis simple zero order and first order partial correlations were worked out for Tamil Nadu state for the variables used in this study and are given below. In pre reform period the correlation between

area and lagged area were positive in the entire study area. This association reveals that a substantial portion of acreage allocation in cotton flows from past behaviour. Equally surprising is the negative correlation found between area and trend in the study region. The relationship between area and variables like rainfall, substitute crop acreage and time trend was not positive in Tamil Nadu state. However the relationship between area and yield was found to be positive in the study region.

In the post reform period, there was positive association between area and lagged area, area and yield, and area and trend value in the entire study region. Cotton acreage and rainfall emerged with a negative signfor the state as a whole. The relationship of area with substitute crop acreage had a mixture of positive and negative signs.

It may be mentioned that no definite indication could be obtained from the zero order correlations worked out for the acreage and non-price variables as the association between them in the state came to be neither uniform nor powerful, not significant enough to suggest any definite choice.

The extent and direction of association between the relative prices was attempted with the help of simple correlation coefficients. P_1 price showed a very good significant association with P_3 price in Tamil Nadu state in pre and post reform periods. All values are positively correlated in the study area. Out of the eight price variables P_3 emerges significantly correlated with remaining price variables in Tamil Nadu state as a whole.

Regressions were run for Tamil Nadu state. The estimated acreage response function based on the selection of price for this state is given below.

Table – 1 Estimation of Zero-Order and First-Order Correlations in Pre-Reform Period

	A_t	A_{t_1}	Y_{t_1}	W_t	T_t	S_t
A_t	1.000	.482(*)	.011	-.017	-.310	-.172
A_{t_1}		1.000	.069	-.341	-.497(*)	-.262
Y_{t_1}			1.000	-.107	.495(*)	-.204
W_t				1.000	.269	.274
T_t					1.000	-.352
S_t						1.000

** Correlation is significant at 0.01 level. * Correlation is significant at 0.05 level.

Table 2 Estimation of Zero-Order and First-Order Correlations in Post-Reform Period

	A_t	A_{t_1}	Y_{t_1}	W_t	T_t	S_t
A_t	1.000	.916(**)	.076	-.040	.915(**)	.750(**)
A_{t_1}		1.000	.063	-.050	.885(**)	.719(**)
Y_{t_1}			1.000	.006	-.017	-.134
W_t				1.000	-.120	-.017
T_t					1.000	.912(**)
S_t						1.000

** Correlation is significant at 0.01 level. * Correlation is significant at 0.05 level.

Table 3 Estimation of Simple Price Correlation Coefficients in Pre-Reform Period

	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8
P_1	1.000	.987(**)	.758(**)	.931(**)	.847(**)	.843(**)	.814(**)	.829(**)
P_2		1.000	.740(**)	.928(**)	.816(**)	.814(**)	.782(**)	.798(**)
P_3			1.000	.938(**)	.965(**)	.963(**)	.963(**)	.964(**)
P_4				1.000	.978(**)	.976(**)	.960(**)	.969(**)
P_5					1.000	.998(**)	.993(**)	.996(**)
P_6						1.000	.995(**)	.999(**)
P_7							1.000	.999(**)
P_8								1.000

** Correlation is significant at 0.01 level. * Correlation is significant at 0.05 level.

Table – 4 Estimation of Simple Price Correlation Coefficients in Post-Reform Period

	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8
P_1	1.000	.931(**)	.625(**)	.850(**)	.914(**)	.901(**)	.824(**)	.907(**)
P_2		1.000	.719(**)	.937(**)	.906(**)	.964(**)	.835(**)	.942(**)
P_3			1.000	.917(**)	.769(**)	.719(**)	.791(**)	.789(**)
P_4				1.000	.914(**)	.923(**)	.885(**)	.946(**)
P_5					1.000	.951(**)	.865(**)	.956(**)
P_6						1.000	.823(**)	.956(**)
P_7							1.000	.952(**)
P_8								1.000

** Correlation is significant at 0.01 level. * Correlation is significant at 0.05 level.

Table – 5 Estimated Acreage Response Functions With Different Price Expectations Used For Cotton Lint Prices In Tamil Nadu In Pre-Reform Period– Logarithmic

Equation No.	Price Expectation used	Constant	P_{t-1}	A_{t-1}	Y_{t-1}	W_t	T_t	S_t	R^2	Adj. R^2
1.01	P_1	59.761	0.370 (0.328)	-0.501 (0.444)	0.707 ** (0.331)	0.501 * (0.346)	-6.835 ** (3.232)	-1.604 ** (0.73)	0.474	0.159
1.02	P_2	49.485	0.179 (0.271)	-0.342 (0.426)	0.659 ** (0.341)	0.497 * (0.359)	-5.269 ** (2.909)	-1.367 ** (0.715)	0.432	0.092
1.03	P_3	39.444	0.271 (0.254)	-0.14 (0.35)	0.53 * (0.307)	0.323 (0.322)	-4.811 *** (2.016)	-0.864 * (0.585)	0.487	0.207
1.04	P_4	53.169	0.527 (0.421)	-0.317 (0.362)	0.6 ** (0.314)	0.325 (0.371)	-7.028 *** (3.127)	-1.174 * (0.597)	0.488	0.18
1.05	P_1	12.290	-0.214 (0.203)	0.255 (0.301)	0.28 (0.301)	0.294 (0.38)	-	-0.377 (0.508)	0.239	-0.106
1.06	P_2	12.268	-0.205 (0.185)	0.25 (0.3)	0.268 (0.291)	0.296 (0.376)	-	-0.372 (0.502)	0.246	-0.097
1.07	P_3	13.349	-0.12 (0.23)	0.255 (0.364)	0.193 (0.322)	0.24 (0.377)	-	-0.441 (0.658)	0.221	-0.103
1.08	P_4	16.023	-0.264 (0.271)	0.159 (0.344)	0.322 (0.338)	0.367 (0.433)	-	-0.593 (0.629)	0.229	-0.122
1.09	P_1	35.999	0.148 (0.266)	-	0.478 ** (0.266)	0.455 (0.348)	-3.892 ** (1.938)	-1.01 ** (0.513)	0.407	0.138
1.10	P_2	34.188	0.07023 (0.231)	-	0.492 ** (0.266)	0.463 (0.351)	-3.477 ** (1.835)	-0.977 ** (0.515)	0.396	0.121
1.11	P_3	34.586	0.288 (0.242)	-	0.456 ** (0.237)	0.295 (0.303)	-4.431 *** (1.713)	-0.718 * (0.441)	0.48	0.263
1.12	P_4	39.916	0.432 (0.403)	-	0.447 * (0.258)	0.312 (0.367)	-5.425 ** (2.508)	-0.876 ** (0.485)	0.448	0.198
1.13	P_5	44.104	0.82 ** (0.389)	-	0.48 ** (0.225)	0.21 (0.321)	-7.466 **** (2.348)	-0.703 * (0.442)	0.566	0.369
1.14	P_6	45.471	0.781 ** (0.426)	-	0.526 *** (0.234)	0.318 (0.319)	-7.603 *** (2.716)	-0.813 ** (0.448)	0.533	0.321
1.15	P_7	46.706	0.885 * (0.514)	-	0.565 *** (0.24)	0.21 (0.347)	-8.307 *** (3.244)	-0.698 * (0.471)	0.52	0.302
1.16	P_8	46.213	0.839 ** (0.469)	-	0.545 *** (0.236)	0.264 (0.33)	-7.993 *** (2.97)	-0.756 * (0.457)	0.528	0.314

*** - Significant at 20% level ** - Significant at 10% level *** - Significant at 5% level **** - Significant at 1% level**
Figures in the Parenthesis are standard errors
P_1 – Twelve – month annual average price in previous year. P_2 – Three – month post-harvest average price in previous year.
P_3 – Three – month pre sowing average price in current year. P_4 – Average of previous years post-harvest and current year pre sowing prices.
P_5 – Three – year average of twelve – month annual average price. P_6 – Three – year average of three – month post-harvest average price.
P_7 – Three – year average of three – month pre sowing average price. P_8 – Three – year average of three – month post-harvest and three-month pre sowing average price

Table 6 Finally, Estimated Cotton Acreage Response Functions – Tamil Nadu in Pre-Reform Period

Equation No.	Price Expectation Selected	Constant	Regression Coefficients						Coefficient of Multiple Determination R^2	Adjusted Coefficient of Multiple Determination $\bar{R}^2$
			Relative Price P_{t-1}	Cotton Acreage in A_{t-1}	Yield Y_{t-1}	Rainfall W_t	T_t	Substitute Crop S_t		
1.03	P_3	39.444	0.271 (0.254)	-0.14 (0.35)	0.53 * (0.307)	0.323 (0.322)	-4.811 *** (2.016)	-0.864 * (0.585)	0.487	0.207
1.04	P_4	53.169	0.527 (0.421)	-0.317 (0.362)	0.6 ** (0.314)	0.325 (0.371)	-7.028 *** (3.127)	-1.174 * (0.597)	0.488	0.18
1.11	P_3	34.586	0.288 (0.242)	-	0.456 ** (0.237)	0.295 (0.303)	-4.431 *** (1.713)	-0.718 * (0.441)	0.48	0.263

* - Significant at 20% level ** - Significant at 10% level *** - Significant at 5% level **** - Significant at 1% level
Figures in the Parenthesis are standard errors

Table – 7 Acreage Elasticities and Coefficient of Adjustment for Cotton Lint Prices in Tamil Nadu in Pre-Reform Period

Equation No	Elasticity with respect to prices		Elasticity with respect to yield	Elasticity with respect to weather	Elasticity with respect to substitute crop	~		Coefficient of adjustment (γ)	Years required for 95 percent effect of price
	Short run elasticity	Long run elasticity							
1.07	-0.069	-0.093	-0.071	-0.088	-0.174	17.92	0.1611	0.7450	2.192
1.11	0.166	0.166	0.158	0.100	0.312	34.59	0.2880	-	-

Table – 8 Estimated Acreage Response Functions with Different Price Expectations Used For Cotton Lint Prices in Tamil Nadu in Post-Reform Period– Logarithmic

Equation No.	Price Expectation used	Constant	P_{t-1}	A_{t-1}	Y_{t-1}	W_t	T_t	S_t	R^2	Adj. R^2
2.01	P_1	36.632	0.0386 (0.291)	-0.702 (0.646)	-0.141 (0.36)	0.781 ** (0.393)	3.134 ** (1.479)	-2.681 (1.657)	0.869	0.803
2.02	P_2	36.744	0.106 (0.27)	-0.761 (0.66)	-0.118 (0.361)	0.8 ** (0.394)	3.269 ** (1.515)	-2.745 (1.646)	0.87	0.806
2.03	P_3	47.703	0.661 *** (0.247)	-1.444 *** (0.577)	-0.307 (0.285)	0.963 *** (0.319)	4.67 **** (1.301)	-3.798 *** (1.37)	0.918	0.877
2.04	P_4	40.040	0.458 * (0.317)	-1.11 * (0.656)	-0.131 (0.326)	0.889 *** (0.371)	4.003 *** (1.49)	-3.195 ** (1.563)	0.888	0.832
2.05	P_1	-6.820	-0.03516 (0.326)	0.629 **** (0.171)	0.302 (0.33)	0.13 (0.276)	-	0.701 * (0.503)	0.82	0.751
2.06	P_2	-6.345	-0.04975 (0.295)	0.627 **** (0.166)	0.288 (0.348)	0.132 (0.276)	-	0.68 * (0.492)	0.82	0.751
2.07	P_3	-12.373	0.264 (0.306)	0.584 **** (0.166)	0.345 (0.305)	0.06501 (0.274)	-	0.992 *** (0.434)	0.829	0.764
2.08	P_4	-9.917	0.106 (0.351)	0.613 **** (0.168)	0.35 (0.331)	0.106 (0.279)	-	0.855 * (0.501)	0.821	0.752
2.09	P_1	15.749	-0.01832 (0.289)	-	0.04794 (0.882)	0.462 * (0.264)	1.572 **** (0.35)	-1.068 * (0.742)	0.856	0.801
2.10	P_2	14.826	0.01655 (0.262)	-	0.06328 (0.329)	0.456 * (0.261)	1.565 **** (0.34)	-1.02 * (0.696)	0.856	0.801
2.11	P_3	7.881	0.359 * (0.255)	-	0.09253 (0.28)	0.363 * (0.249)	1.49 **** (0.321)	-0.645 (0.636)	0.875	0.827
2.12	P_4	10.182	0.219 (0.303)	-	0.125 (0.309)	0.414 * (0.259)	1.538 **** (0.335)	-0.79 (0.694)	0.862	0.808
2.13	P_5	4.781	0.543 (0.419)	-	0.184 (0.299)	0.361 * (0.254)	1.501 **** (0.324)	-0.57 (0.682)	0.872	0.823
2.14	P_6	8.511	0.321 (0.394)	-	0.18 (0.33)	0.429 * (0.253)	1.558 **** (0.331)	-0.768 (0.685)	0.863	0.81
2.15	P_7	9.443	0.364 (0.387)	-	0.02451 (0.291)	0.414 * (0.253)	1.585 **** (0.329)	-0.799 (0.646)	0.865	0.813
2.16	P_8	8.065	0.385 (0.419)	-	0.124 (0.3)	0.414 * (0.254)	1.569 **** (0.329)	-0.746 (0.675)	0.865	0.813

*** - Significant at 20% level ** - Significant at 10% level *** - Significant at 5% level **** - Significant at 1% level**
Figures in the Parenthesis are standard errors
P_1 – Twelve – month annual average price in previous year. P_2 – Three – month post-harvest average price in previous year.
P_3 – Three – month pre sowing average price in current year. P_4– Average of previous years' post-harvest and current year pre sowing prices.
P_5 – Three – year average of twelve – month annual average price. P_6 – Three – year average of three – month post-harvest average price.
P_7 – Three – year average of three – month pre sowing average price. P_8 – Three – year average of three – month post-harvest and three-month pre-sowing average price

Table – 9

Finally, Estimated Cotton Acreage Response Functions – Tamil Nadu in Post Reform Period

Equation No.	Price Expectation Selected	Constant	Regression Coefficients						Coefficient of Multiple Determination R^2	Adjusted Coefficient of Multiple Determination $\bar{R}^{-2}$
			Relative Price P_{t-1}	Cotton Acreage in A_{t-1}	Yield Y_{t-1}	Rainfall W_t	T_t	Substitute Crop S_t		
2.03	P_3	47.703	0.661 *** (0.247)	-1.444 *** (0.577)	-0.307 (0.285)	0.963 *** (0.319)	4.67 **** (1.301)	-3.798 *** (1.37)	0.918	0.877
2.04	P_4	40.040	0.458 * (0.317)	-1.11 * (0.656)	-0.131 (0.326)	0.889 *** (0.371)	4.003 *** (1.49)	-3.195 ** (1.563)	0.888	0.832
2.11	P_3	7.881	0.359 * (0.255)	-	0.09253 (0.28)	0.363 * (0.249)	1.49 **** (0.321)	-0.645 (0.636)	0.875	0.827

* - Significant at 20% level ** - Significant at 10% level *** - Significant at 5% level **** - Significant at 1% level

Figures in the Parenthesis are standard errors

Table – 10 Acreage Elasticities and Coefficient of Adjustment for Cotton Lint Prices in Tamil Nadu in Post-Reform Period

Equation No.	Elasticity with respect to prices		Elasticity with respect to yield	Elasticity with respect to weather	Elasticity with respect to substitute crop	~		Coefficient of adjustment (γ)	Years required for 95 percent effect of price
	Short run elasticity	Long run elasticity							
2.07	0.189	0.454	0.297	0.362	0.677	29.74	0.6346	0.4160	5.570
2.11	0.257	0.257	0.168	0.205	0.383	7.88	0.3590	-	-

Estimation of Cotton Acreage Response in Tamil Nadu state

PRE REFORM PERIOD

Table 5 gives the regressions relating acreage and other variables with alternative price specifications. Equations 1.01 to 1.04 reveal that coefficient of relative price is positively significant in all equations. Added to this past yield, rainfall have also turned out to be positive for these equations. The inclusion of past acreage, yield, trend and substitute crop acreage emerge negatively significant. $\mathbf{R^2}$ value is high for both P_3 and P_4 prices. With the exception of P_{t_1} and S_t all other variables are positively significant from equations 1.05 to 1.08. In the traditional model T_t and S_t are found to be negatively significant. P_5 price specification has the highest adjusted $\mathbf{R^2}$ value (Table 5).

Table 6 shows acreage elasticities and coefficient of adjustment of cotton lint prices in Tamil Nadu in pre-reform period. The short run and long run elasticity with respect to price are low but positive. For the entire state, it takes nearly 2 years for full adjustment when P_3 price is taken into account (Table 7).

POST REFORM PERIOD

In the post reform period (Table Nos. from 8 to 10) P_3 price gave the best results P_{t_1}, W_t and T_t are found to be positive with different levels of significance. The short run and long run elasticity with respect to price are not significant. The coefficient of adjustment was very low and the state takes 6 years for full adjustment in the recent time period.

CONCLUSION

The main finding that could emerge from this study is that the acreage responds positively to price changes and it is very much influenced by non-price factors. The eight price specifications seldom give identical results with respect to farmer's acreage decisions. The results of the regression indicate that P_3 price is the most relevant price at the rstate level in explaining farmer's decisions.

In the state as a whole though the farmers take 2 to 6 years to fully adjust the acreage to change in its price, it is quite clear from the study that price behaviour is at best a decisive factor for area allocation for cotton in Tamil Nadu state in conjunction with factors like rainfall, prices of the competing crops, yield and past acreage. The magnitude of γ varies from one price to another price variable. Higher value of γ indicates that large number of past prices are considered in acreage allocation decision. The regression co-efficient reveals that a high value of coefficient of adjustment indicates lesser rigidity in adjustment of output. The study broadly endorses the conclusion that the adjustment lag model yields better results when compared with traditional model as it yields good values for the variables considered for the present study. It is concluded that the importance of price is unquestionable from the view point of stability or the increase in cotton acreage. Price then plays an important role in acreage allocation decisions of the farmers.

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