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SUGARCANE ACREAGE RESPONSE IN SINDH - PAKISTAN

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This paper attempts to explain the acreage allocation behaviour of sugarcane cultivators in terms of their responsiveness to price and non-price factors over the period, 1972-73 to 1993-94. Specifically, the paper estimates the elasticities of sugarcane acreage in Sindh and its districts with respect to the crops' (i) relative profitability, (ii) irrigation, (iii) risk variable arising from price and yield, (iv) area under plant protection measures and (v) sugar production by factories. Through its adjustment coefficient the model estimates the degree of farmers' realisation of various incentives provided to them.

I. Introduction

The debate on the importance of economic variables like supply, demand and prices and how today's farmers respond to them has gained importance during the last few decades. In the developed world the supply phenomena is of crucial importance especially in order to control surpluses, raise farm incomes and enhance resource productivity. It is therefore, high time for the developing countries to gear up to these needs and try and understand the supply phenomena of crops in order to effectively implement the viable policies.

Like other developing countries, the topic of supply response has been studied in Pakistan by various authors, such as Krishna (1963), Falcon (1964), Cummings (1975), Hussain (1964) and many others. Most of these studies are more than two decades old. Since then number of technical, institutional and economic changes have taken place in Pakistan's agriculture. However, recently efforts have been made by Ashiq (1981), Tweeten (1986), Ali (1988), Khan and Iqbal (1991) and Naqvi and Burney (1992) to study the issue in this changed environment. Using Nerlovian Adjustment Model, Ashiq and Tweeten found that the farmers of Pakistan are rational and respond positively to economic

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incentives. On the other hand, Ali (1988) concluded that the price support policy of the government has little potential to increase overall agricultural production. Khan and Iqbal also used the Nerlovian partial adjustment adaptive expectational model for ten major crops of Pakistan. They concluded that farmers in Pakistan tend to behave 'rationally' in general. Although it is found that farmers are price-responsive, but the degree of responsiveness differs from crop to crop. Naqvi and Burney estimated output supply and input demand functions based on the profit function approach.[1] Their results confirmed that Pakistani farmers respond to changes in output prices.

Sugarcane is the most important cash crop of Sindh. It provides the much needed cash requirement to a large number of subsistence farmers and caters to the raw material needs of sugar factories in the province. In 1993-94 sugarcane is cultivated on over 963 thousand hectares in the country, in which Sindh's share is 266 thousand hectares, thus it contributes about 35 per cent of the total production. The five major sugarcane growing districts, namely Badin, Hyderabad, Nawabshah, Tarparkar and Thatta are chosen for our analysis. Twenty three percent of Sindh's cane acreage falls in Badin, 20 per cent in Hyderabad, 21 per cent in Nawabshah, 9 per cent in Tharparkar and 8 per cent in Thatta. The acreage under sugarcane in the province expanded from 79 to about 266 thousand hectares between 1972-73 and 1993-94. Wide fluctuations in the acreage have always been a matter of concern in the past but have assumed more grave dimensions recently.

II. Hypothesis

The present study is based on the hypothesis that area under sugarcane responds to stimuli like relative profitability, irrigation, price and yield risk, plant protection measures and sugar production by factories.

III. Sources of Data

To build up an economic model on this hypothesis it is necessary to have adequate data relating to the area under sugarcane and the said stimuli in order to make a quantitative assessment. The study is based on secondary data at district and provincial levels. The analysis is mainly based on the data drawn from various issues of the Agricultural Statistics of Pakistan, published by the Government of Paksitan and the Development Statistics of Sindh, published by the Government of Sindh. The study covers a period of 21 years spanning from 1972-73 to 1993-94.

[1]Short-run own and cross-price elasticities based on earlier studies are reorted in Table 1.

TABLE 1

Short--run Own and Cross-price Elasticities based on Earlier Studies

Reference	Specification	Prices of					
		Wheat	Cotton	Rice	Sugarcane	Maizze	Input
Falcon. 1964	Acreage						
	1) Wheat (i)	0.1-0.2	-	-	-	-	-
	Wheat (b)	n.s.	-	-	-	-	-
	2) Cotton	-	0.400	-	-	-	-
	3) Cotton Yield	-	n.s.	-	-	-	-
Cummings, 1975	Output						
	1) Wheat	0.1 n.s.	-	-	-	-	-
	2) Cotton	-	0.400	-	-	-	-
	3) Rice	-	-	0.120	-	-	-
Hamid, et al, 1987	Acreage						
	1) Wheat Yield	0.090	-	-	-	-	-0.090
	Wheat	0.340	-0.030	-	-	-	-
Ahmed, et al, 1983	Acreage						
	1) Wheat	0.100	-	-	-	-	-
	2) Rice	-	-	0.160	-	-	-
	3) Sugarcane	-	-0.110	-	0.410	-	-
	Output						
	1) Wheat	0.280	-	-	-	-	-
	2) Rice	-	-	-	-	-	-
	3) Sugarcane	-	-	-	0.700	-	-0.570
Tweeten, 1986	Output						
	1) Wheat	0.150	-0.02	-0.004	-0.007		-0.119
	2) Cotton	0	0.300	-0.010	-0.015	-	-0.275
	3) Rice	0	-0.028	0.200	-0.009	-	-0.163
	4) Sugarcane	0	-0.043	-0.009	0.300	-	-0.248
Chaudhry and Bashir, 1986	Acreage						
	1) Wheat	n.s.					
	2) Cotton	-	0.055			-	
	3) Rice	-		0.342		-	
	4) Maize	-	-	-	-	0.148	-
Ali, 1988	Output						
	1) Wheat	0.230	-0.150	0.170	0	0	-0.250
	2) Cotton	0	0.720	-0.330	0	0	0.020
	3) Rice	0.140	-0.100	-0.140	0	-0.080	0.010
	4) Sugarcane	0	-0.150	0	0.520	0	0.020
	4) Maize	0	-0.210	0	--0.100	0.360	0.030

TABLE 1

continued

		Prices of					
Reference	Specification	Wheat	Cotton	Rice	Sugarcane	Maizze	Input
Khan and Iqbal, 1991	1) Wheat	0.070	-	-	-	-	-
	2) Cotton	-	0.60	-	-	-	-
	3) Rice	-	-	0.130	-	-	-
	4) Maize	-	-	-	-	0.160	-
	Yield						
	1) Wheat	0.020	-	-	-	-	-
	2) Cotton	-	0.140	-	-		-
	3) Rice	-	-	0.05	-	-	-
	4) Sugarcane	-	-	-	0.520	-	-
	5) Maize	-	-	-	-	0.010	-
Naqvi and Burney, 1992	Acreage						
	1) Wheat	0.086	-	-	-	-	-
	2) Rice	-	-	0.039	-	-	
	3) Maize	-	-	-	-	0.074	-

i) = irrigated, (b) = brani.

IV. The Analytical Framework

The farmers face a number of constraints while making production decisions in response to changes in the economic environment which results from various economic stimuli. The farmer allocates his land to different crops, depending upon his expected revenue from them. Assuming that the input costs are same or more uniformly distributed over time for different crops, the expected revenue depends upon the expected price. Under such conditions the Adjustment Lag Model is considered appropriate and widely used by a number of researchers in their acreage response studies. We have also chosen the Nerlovian Adjustment Lagged Model[2] [Nerlove (1958)] for the analysis.

[2] Researchers have preferred to use the Adjustment Lag Model instead of the traditional model because it is said to present a more realistic picture by incorporating distributed lags and thereby introducing a realistic assumption about the farmers' adjjustment behaviour (in the traditional model, adjustment is assumed to be instantaneous). The other advantage of the adjustment lag model claimed by Nerlove is that, as compared to the traditional model, it explains the data better by yielding coefficients, more reasonable in sign and magnitudes,, and thereby provide better estimates of supply elasticities. Further, it eliminates and/or reduces the incidence of serial correlation in the residuals.

The long-run supply A^*_t is assumed, in the Nerlovian framework, to be related to P_t (the price) in a simple linear manner:

$$A^*_t = a + bP_{t-1} + U_t \quad (1)$$

Variations in A^*_t are connected by variations in observed or actual supply by assuming the following relationship between the actual and long-run desired level of supply:

$$A_t - A_{t-1} = \beta(A^*_t - A_{t-1}) \; 0 \leqslant \beta \leqslant 1 \quad (2)$$

The current supply then is:

$$A_t = A_{t-1} + \beta(A^*_t - A_{t-1}) \quad (3)$$

β is the coefficient of adjustment, which accounts for the forces which cause the difference between the short-run[3] and long-run[4] supply-price elasticities. The first equation is a behavioural relationship, stating that the desired acreage under the crop studied depends upon the relative farm prices in the preceding year. The second equation is the partial-area-adjustment equation in which 'β' is the coefficient of adjustment. The farmers, it is hypothesised, are able to change the acreage of the crop in any year only to the extent of a fraction 'β' of the difference between the acreage they would like to plant and the acreage actually planted in the preceding year. 'β' is, therefore, an indication of how fast the farmers are adjusting themselves to their expectations. The value of 'β' close to zero would mean that the farmers are slowly adjusting to the change in prices, yield, etc. The value of 'β' close to one would mean that the farmers are adjusting to the changing levels of prices, yield, etc., almost instantaneously.

By substituting the value of A^*_t in equation (2) we get:

$$A_t = A + BP_{t-1} + CA_{t-1} + V_t \quad (4)$$

where $A = a\beta$; $B = b\beta$; $C = (1-\beta)$, and $V_t = \beta U_t$

Equation (4) is a computational equation, parameters of which are estimated by the least square method. The reduced form would basically remain the same, even if we include more independent variables. This model is also

[3] The time period during which the fixed factors of production cannot be changed,, but the level of utilization of variable factors can be altered.

[4] The long run elasticity is the response after all expectational variables have adjusted to the initial change.

helpful in the estimation of both the short-run and long-run supply elasticities.

Using the Adjustment Lag Model as the basic frame for analysis, the response relationship in the study was estimated with the help of the following short-run equation:

$$\log A_t = \log\alpha + \beta_1 \log RP_{t-1} + \beta_2 \log I_{t-1} + \beta_3 \log CV_p + \beta_4 \log CV_y + \beta_5 \log PP_{t-1} + \beta_6 \log SP_{t-1} + \beta_7 \log A_{t-1} + \log V_t$$

where

At = Acreage under sugarcane in year t;

RP_{t-1} = Relative profitability[5] measured in terms of relative gross return per acre in year t-1. Per acre relative gross return of sugarcane with respect to competing crop was estimated as:

$$\frac{\text{Procurement/support price of sugarcane x per acre yield}}{\text{Wholesale price of competing crop x per acre yield}}$$

I_{t-1} = Irrigated area under all crops in year t-1;[6]

CV_p = coefficient of variations of the ppricces of sugarcane for the years t-1, t-2, t-3, used as a measure of price risk;

CV_y = coefficient of variations of the yields of sugarcane for the years t-1,, t-2, t-3, used as a measure of yield risk;

PP_{t-1} = area under plant protection measures (only for province) in year t-1;

SP_{t-1} = sugar production by vacum pan factories (only for province) in year t-1;

A^*_t = desired or long-run area under the crop in year t;

A_{t-1} = area under the crop in year t-1;

V_t = error term in year t;

β = adjjustment coefficient.

In our analysis, only one important substitute crop per district and province is selected. This may help in understanding the conditions prevailing in Sindh, where the number of competing crops to major crops is one or are very few. The studies by Lal and Singh (1981) and Satyanarayana (1967) on

[5] The prices of crops have not been taken. Instead, a measure of relative profitability has been used. as a variable instead of relative pricec. For deflating the sugarcane prices the composite index of prices based on the prices of wheat,, rice and cotton were also tried, but yielded poor results consistently.

[6] Lagged irrigated area was used. Propportion of irrigated area to total area was also tried as an alternative variable.

sugarcane have also used only one competing crop for each region/state.[7]

Even for the same crops, substitutes will vary from district to district. In selecting the substitute crops we have taken into account the sowing and growing period of different crops in both the seasons. An inter-correlation matrix of the changes in area under sugarcane and their substitute crops are fitted for different districts and results taken into account while selecting the substitute crop. Another consideration was that the selected substitute crop was a major crop in the respective districts.

The competing crops selected in the study are wheat, in Badin and Hyderabad, cotton, in Nawabshah, Tharparkar and Sindh rice, in Thatta. Multiple log-linear regression using Ordinary Least Squares (OLS) technique is used to estimate the coefficients in the acreage supply functions. The log form of the function consistently yielded better results with respect to signs, values and levels of significance of the regression coefficients. Besides, the logarithmic forms also provide direct estimates of short-run elasticities.

The long-run elasticities were calculated by using the short-run elasticities in the following way:[8]

$$\text{Long-run price elasticity of acreage} = \frac{\text{short-run elasticity}}{\text{coefficient of adjustment}}$$

V. Results and Interpretation

The results of multiple log-linear regression and its short-run and long-run price elasticities are presented in Table 2. The explanatory power of all the

[7] More than one competing crops were also tried in the equation for each district and province but it yielded consistently poor results with respect to signs, values and level of significance of the regression coefficients.

[8] The Durbin-watson statistics to test far auto correlation is not calculated since this model includes a lagged dependent variable in the set of regressors. In the presence of a lagged dependent variable (lagged acreage for example) in a regression equation, the DW d-statistic is likely to have reduced power and is biased toward the value 2, Durbin (1970) and Nerlove (1966). For such an equation, Durbin has suggested an alternative test statistic know as lagrange Multiplier Test or the h-statistic, defined as:

$$h = (1 - \tfrac{1}{2}d)\sqrt{\frac{n}{1 - n\hat{v}(\hat{\beta}_7)}}$$

where,

$\hat{v}(\hat{\beta}_7)$ = least squares estimate of variable b_7

d = usual DW d-statistic

n = number of observations

The test statistic can also be used to test the hypothesis of no serial correlation against first-order autocorrelation, even if the set of regressors in an equation contains higher order lags of the dependent variable.

equations is high because the values of R^2 are more than 0.90 in all districts and the province. Since $\hat{v}(\hat{\beta}_7)$ is < 1/n, the computation of h-statistics is possibble. The computed Durbin's h-statistics ($< \pm 1.645$) indicates no serial correlation in all districts and in the province.

(a) Lagged Relative Profitability

The impact fo relative profitability on sugarcane acreage is positive and significant at the 5 percent level in Nawabshah, Tharparkar and Sindh province, while in Badin and Hyderabad, it is significant at 10 per cent level. This suggests that additional income from the crop in the preceding year generally leads to higher investment in the acreage of sugarcane crop in Nawabshah, Tharparkar, Badin, Hyderabad and Sindh province. This, in a way, suggests that for a producer, growing of competing crops, mainly for family consumption, is of little importance. In Thatta, the coefficient of this variable is positive but statistically insignificant.

(b) Lagged Irrigated Area

The coefficient of irrigation is postive and significant at the 5 percent level in Badin and Sindh province, while in Nawabshah and Tharparkar, it is significant at the 10 percent level. The positive acreage irrigation response points to the fact that farmers will shift to sugarcane cultivation if irrigation facilities are improved.

(c) Price and Yield Risk

Of the two risk variables, the variability due to price gives expected negative sign for Badin and Tharparkar districts. The coefficient is only significant at the 5 percent level in Badin. The negative sign of the price risk variable indicates that sugarcane growing farmers appear to be risk-takers by putting less acreage under the crop. In other districts and the province, the coefficient is positive but statistically insignificant. The negative sign of variability due to yield upholds our a priori expectation in Hyderabad, Tharparkar and Sindh province, however the coefficient of this variable is significant at 5 per cent level in Tharparkar district only. In other districts, the coefficient is positive but statistically insignificant. The unexpected sign in the model for price and yield risk variables may be due to a continuous trend in the price and yield levels of the crop concerned. If some crops have continuous expected trend in price or yield, expected variability may predominate the total variability and reveal an unexpected sign for the risk variable.

TABLE 2

District-wise Estimated Regression Coefficients of Acreage Response Functions for Sugarcane in Sindh

District/ Province	Major Competing Crops	Constant	Regression Coefficients							Coefficient of Adjustment	Multiple Coefficient of Determination	Durbin 'h' Statistics	Relative Profitability	
			Relative Profitability in t–1	Irrigated Area in t-1	Price Risk	Yield Risk	Area Under PlantProtection Measure in t-1	Sugar Production in t-1	Suugarcane Acreage in t-1				Short-run Elasticity	Long--run Elasticity
		α	RP_{t-1}	I_{t-1}	CV_p	CV_y	PP_{t-1}	SP_{t-1}	A_{t-1}	β	R^2	'h'	SRE	LRE
Badin	Wheat	7.249	0.210 ((1.999)^c	0.544 (2.406))^b	-0.066 (2.497)^b	0.021 (1.134)			0.865 (5.825)^a	0.135	0.913	0.206 (NSC)	+0.210^c	+1.555^c
Hyderabad	Wheat	7.790	0.225 (1.785)^c	0.206 (1.231)	0.193 (1.526)	-0.030 (1.184)			0.843 (5.483)^a	0.157	0.949	0.301 (NSC)	+0.225c	+1.433^c
Nawabshah	Cotton	-1.791	0.189 (2.174)^b	0.223 (1.854)^c	0.002 (0.094)	0.037 (1.662)			0.873 (6.188)^a	0.127	0.931	0.109 (NSC)	+0.189^b	+1.488^b
Tharparkar	Cotton	5.396	0.515 (2.637)^b	0.230 (1.801)^c	-0.046 (1.049)	-0.103 (2.195)^b			0.761 (5.878)^a	0.239	0.907	0.406 (NSC)	+0.515^b	+2.155^b
Thatta	Rice	-4.408	0.032 (1.154)	0.400 (0.470)	0.117 (1.091)	0.135 (1.247)			0.914 (5.832)^a	0.086	0.900	0.140 (NSC)	+0.032	+0.372
Sindh Province	Cotton	5.510	0.216 (2.165)^b	0.255 (2.607)^b	0.009 (0.496)	-0.010 (0.703)	0.042 (2.101)^c	0.022 (0.516)	0.802 (9.100)^a	0.198	0.983	0.102 (NSC)	+0.216^b	+1.091^b

Note: Figures in parentheses are t-values; a = Significant at one per cent level; b = Significant at 5 per cent level; c = Significant at 10 per cent level; NSC = No Serial Correlation.

(d) Lagged Area Under Plant Protection Measures

The regression coefficient for the area under plant protection[9] variable turns out to be positive and significant at the ·10 per cent level in the province. The positive response of farmers, however, indicates that sugarcane growers do not altogether ignore the effects of plant protection measures while allocating the land to the crop.

(e) Lagged Sugar Production[10]

This variable is included to see whether sugarcane growers are influenced by variations in factory output. Sugar production by sugar factories in Sindh do not have a direct bearing on acreage under sugarcane, because the coefficient of this variable is insignificant. Indirectly, this means that the mill price is not attractive enough to the producer and that there is insignificant regulation in cane supply to sugar factories at the provincial level.

(f) Lagged Sugarcane Acreage

The elasticity estimates of lagged sugarcane acreage are found to be positive and significant at the 1 per cent level in all districts and the province. The magnitude of the coefficient is high, indicating a lower rate of adjustment of farmers.

(g) Adjustment Behaviour and Short-run and Long-run Price (Relative Profitability) Elasticities

The pace at which the farmers adjust the acreage under a crop in response to the movements in factors discussed above, may be seen from the numerical values of the adjustment coefficient (β). A low rate of adjustment is observed in all districts and the province, indicating that acreage is influenced more by technological and institutional rigidities and that price inducements operate slowly and gradually. As expected, the long-run elasticity with respect to relative profitability is higher than short-run elasticity in all districts and the province, which is indicative of the long-run adjustment of the area under the crop.

A comparison of the price elasticities of acreage obtained, with the elasticities of acreage estimated by other authors in Pakistan, Bangladesh and India are

[9] District-wise area under plant protection measures was not available,, therefore this variable was captured only in the province equation.

[10] Nearness to sugar mill may be an important determinant in the sugarcane acreage regression but published data on this variable is not available. Data on sugar production by factories was available at province level,, therefore this variable was used instead.

presented in Table 3. It indicates that our estimated sugarcane acreage elasticity in the long-run, with respect to relative profitability of sugarcane, is higher than short-run as compared to Bangladesh, Indian Punjab and Haryana, which supports the long-run adjustment of the area in our analysis.

VI. Conclusions and Policy Implications

The result of the analysis reveal that in the process of making the area decisions for sugarcane cultivation, variables like relative profitability, irrigation, plant protection measures and lagged acreage are more important. The farmers in Badin, Hyderabad, Nawabshah, Tharparkar and Sindh province respond positively to relative profitability. Irrigation, the potential variable for adoption of modern inputs has a positive and significant impact in Badin, Nawabshah, Tharparkar and Sindh province. This points to the fact that farmers will shift to sugarcane crop if irrigation is improved. In Badin and Tharparkar our result emphasize the need for minimising the price and yield risk. The unexpected sign in the model for price and yield risk variables may be due to a continuous trend in the crop's yield and price levels.

The sugar-cane growers in Sindh consider and are aware of the effects of plant protection measures. The Agriculture Department should, therefore, provide pesticides to small farmers at discounted rates. Area lagged by one year is found to be positive and significant in all districts and the province. The main

TABLE 3

Sugarcane Price Elasticities of Acreage for some Developing Countries

Province/State/ Region/Country	Period	Short-run Price Elasticity	Long-run Price Elasticity	Source
Sindh, Pakistan	1972-94	+0.16*	+1.091*	Our Estimates
Pakistan	1960-81	+0.41	-	Nuzhat Ahmad
Punjab, Pakistan	-	+0.2242	-	Chaudhry and Bashir
Bangkadesh	1972-81	+0.34	+0.51	Sultan H. Rehman
Bangkadesh	947-82	+0.360	+0.435	Jaforullah
Punjab, India	1915-43	+0.17	+0.30	Raj Krishna
Haryana, India	1960-76	+0.44	--6.9	S.S. Sang Wan
Uttarpradesh, India	1950-74	+0.415	+1.600	Lal and Singh

*Relative profitability.

reason for this may be that farmers follow some traditions and do not change the area of crop easily. Their own requirements of food, ignorance about appropriate cropping pattern, (owing to illiteracy and other traditional and social factors), and a lack of knowledge for suitable competing crops may be possible causes. In all districts and the province, a low value of the coefficient of adjustment indicates a slow adjustment process. The long-run elasticity with respect to relative profitability is higher than short-run elasticity in all districts and the province, which is indicative of the long-run adjustment of the area.

The results obtained in this study may have important implications for policy formulation. First, the varietal improvements in sugarcane crop and the adoption of such varieties by farmers having a comparative advantages (technological, institutional and others) are important for maintaining production at the desired levels. Second, results of the study indicate a positive response of land resource allocation to prices. This means that farmers may adjust their acreage allocation to sugar cane as a response to relative prices of sugar cane and substitute crops. Therefore in order to bring about an effective adjustment in acreage allocations, support prices for various crops must be announced well before the sowing season and such prices should carry a long-run guarantee. This policy will not only enable the farmers to plan their production programmes better but may also help to correct the inter-commodity imbalance to some extent.

Third, price and risk factors need to be considered to provide the necessary incentives to the producers to maintain sugarcane acreage at desired levels. Finally, government should make thorough investigations into the allegations regarding the purchase of sugarcane by mills and take corrective measures. Fair trading practices will also encourage potential marginal farmers to grow more sugarcane.

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