Ind. Jn. of Agri. Econ.
Vol.67, No.4, Oct.-Dec. 2012

Supply Response of Sugarcane in India: Results from All-India and State-Level Data

Lokendra Kumawat and Kamta Prasad*

I

INTRODUCTION

The past few years have seen wild fluctuations in sugar prices. Sugar, being a basic component of the food basket of all strata of the society, such fluctuations have attracted attention of the policy makers as well as academicians. To design policy measures to manage these fluctuations the policymakers need to look at both demand and supply of sugar. The supply of sugar depends to a great extent on the production of sugarcane. Therefore, reducing fluctuations in sugarcane production would be one way to stabilise sugar prices. It is in this context that a thorough analysis of the factors responsible for the variations in the sugarcane output is needed.

This study, therefore, attempts to estimate the supply response function for sugarcane. It has been done for All India as well as for Uttar Pradesh and Maharashtra, the two largest producers of sugarcane in India. This is done in the framework of partial adjustment model of Nerlove (1958). We estimate partial adjustment models separately for area and yield, the latter capturing responsiveness of factors other than area. We find that while area is affected by sugar prices primarily, the yield is affected mainly by rainfall. In fact, in Maharashtra rainfall affects area also. Finally, we find that addition of sugarcane price arrears as an explanatory variable improves the explanatory power of the models significantly showing the important role of this variable in determination of sugarcane production.

The rest of the paper is organised as follows. The next section discusses the econometric model used in the study and the related methodological issues. Section III reviews some recent studies in this direction. This is followed by a discussion of the data and methodology of this paper in Section IV. Section V contains discussion of results, followed by conclusions in Section VI.

II

MODEL AND METHODOLOGICAL ISSUES

There are two important aspects of the methodology: (i) basic modeling framework, and (ii) specification of variables.

*Assistant Professor, Department of Economics, Ramjas College, University of Delhi, Delhi – 110 007 and Chairman, Institute for Resource Management and Economic Development, Delhi – 110 092, respectively.

2.1 *Broad Modeling Framework*

We model the behaviour of the decision variable(s) of the farmers using the partial adjustment model of Mark Nerlove. This model has the advantage that it allows explicitly for slow adjustment of response of the variable being studied to any change in the determinants. Even the speed of adjustment is estimated within the model. This slow adjustment is particularly important for a developing country like India where a number of factors hinder a farmer's immediate response to the incentives. These factors include the credit constraints, lack of availability of desired inputs in time, etc.

Specifically, if y_t is the variable whose responsiveness is to be modeled and Z_t is the vector of regressors, the partial adjustment model differentiates between the actual level y_t of the variable and the desired level, y^d_t, which the farmer desires to attain, given the values of the decision variables. The desired value thus responds to the explanatory variables according to the equation

$$y^d_t = \theta' Z_t + \varepsilon_{1t} \quad \text{….(1)}$$

The actual level then adjusts towards this level according to the equation

$$y_t = y_{t-1} + \lambda(y^d_t - y_{t-1}) + \varepsilon_{2t} \quad \text{….(2)}$$

where λ gives the speed adjustment to the desired level. This means that the change in any given period is proportional to the gap between the actual and desired levels in the previous period. A low value of this parameter (close to zero) means very slow adjustment, while a large value shows fast adjustment.

The parameter vector θ and the adjustment parameter λ can be estimated simultaneously. For this, substituting for y^d_t from equation (1) into (2) we get the reduced form equation

$$y_t = y_{t-1} + \lambda(\theta' Z_t + \varepsilon_{1t} - y_{t-1}) + \varepsilon_{2t}$$

which gives on rearrangement

$$y_t = (1- \lambda)\, y_{t-1} + \lambda\theta' Z_t + \nu_t \quad \text{….(3)}$$

Where $\nu_t = \lambda\varepsilon_{1t} + \varepsilon_{2t}$

This equation can be estimated using the standard estimation methods. From the estimation results for this reduced form equation one can recover the speed parameter λ as well as the structural (long-term response) parameters θ. Specifically the (1 – coefficient of y_{t-1}) gives the value of the adjustment parameter, and dividing coefficient estimates of the other independent variables gives the long-run responsiveness (responsiveness of y^d_t) to the variable concerned.

2.2 *Specification of Variables*

This decision involves two types of variables: (a) the decision variable of the farmer, or the dependent variable, and (b) the explanatory variables.

2.2.1 *Decision Variable of the Farmer*

In the literature, the decision of the farmer regarding input use is divided in two parts: area under a crop, and the other inputs. The idea is that the farmer can respond to the incentives either by changing the area under the crop or by changing other inputs, which might include, e.g., adopting better technology, irrigation facilities, etc. Area can be measured directly. Of the other variables, some may not be measured directly, or there may be problems with their measurement. One common method used in the literature to solve this problem is to model the yield (production per unit area), which captures effect of all the other factors. Thus, a study of determinants of a particular crop comprises studies of determinants of area under a crop and yield. Total output, then, is simply the product of area under a crop and yield; and thus these two variables taken together capture the complete variation in the crop.

2.2.2 *The Independent Variables*

The variables affecting the decision of the farmer regarding area and/or other inputs can be divided into two broad categories: (i) the profit variable (the incentive variable), and (ii) the other variables, which include enabling factors (such as rural public investment, irrigation and rainfall) and risk factors (such as price risk and yield risk).

The Profit Variable

This variable captures the economic return the farmer would get by sowing the crop. The first question facing the researcher with regard to this variable is the exact variable to be taken. In the early studies in this area, the absolute profitability of the crop under consideration was taken. Subsequently, this variable was replaced by relative profit variable. Thus, one could take ratio of profit for the crop being considered with that for the substitute crop. If there is more than one substitute possible, one can take some average of the profits from the substitute crops.

Calculation of profits has its own measurement problems such as identifying proper imputation methods for own inputs, appropriate type of costs to compute profits and the problems related to common costs. One solution to this problem is to look at the final price of the product only. Even then there is the question of which price to take. One common practice in the literature is to use the wholesale price index for the commodity concerned. However, it is argued by some researchers (e.g., Kanwar, 2006) that this variable is not a good indicator of prices that the farmer receives, and, therefore, is not the variable that guides his/her decision. This is because of the fact that the wholesale price index tracks the average price prevailing over the year in the wholesale markets. This does not represent the price reaching the farmer's hands, at least in India, since most farmers lack storage facilities and, therefore, sell their output immediately after harvest. Therefore, the prices they get are the farm harvest prices. Thus farm harvest prices could be expected to capture the farmers' price response better than the wholesale price index. The latter tend to be close to the farm harvest prices around the time of harvest but can be much higher during the rest of the year.

In the case of sugarcane, there is an additional price variable. Since most of the sugarcane production is for production of sugar, the price of sugar provides an indication of the price that the farmers might be able to receive. Therefore, sugar price is an additional variable that can be tried here.

However, the actual price the product would fetch is known only after crop reaches the market, while the decision regarding total inputs to be used need to be taken much before. Due to this, the decision is governed by the expectations the farmers have, of the relevant price variable. The second issue in selecting the incentive variables, therefore, is modeling of expectations. In the literature four types of expectation formation mechanisms have been used most commonly, to model the behaviour of farmers: (i) Naïve expectations, (ii) Extrapolative expectations, (iii) Adaptive expectations and (iv) Rational or Quasi-rational expectations. Each of these mechanisms has its own merits and demerits and, therefore, prima facie it is difficult to select or reject any one of them. These mechanisms are discussed in detail in the literature, e.g., Nerlove and Bessler (2001), and a brief description is given below.

Naïve Expectations: Naïve expectation means expected price is equal to the actual price in the previous period, i.e., $\Pi^e_t = \Pi_{t-1}$ ....(4)

Extrapolative Expectations: This is an extension of the naïve approach to expectation formation. According to this approach, expectation of value of the variable in period 't' is the actual value in period t-1 plus a fraction of the change in the value of this variable from period t-2 to t-1, i.e.,

$$\Pi^e_t = \Pi_{t-1} + \alpha(\Pi_{t-1} - \Pi_{t-2}) \qquad 0 < \alpha < 1 \qquad \text{....(5)}$$

Adaptive Expectations: According to the adaptive expectations hypothesis, expectations are revised between two periods in proportion to the discrepancy between actual value and expectation in the previous period. It can be written as

$$\Pi^e_t = \Pi^e_{t-1} + \beta(\Pi_{t-1} - \Pi^e_{t-1}), \; 0 < \beta < 1 \qquad \text{....(6)}$$

While in this form adaptive expectations can be incorporated into an econometric model, incorporating these into partial adjustment framework leads to identification problem (see, e.g., Maddala, 2002), if the model is estimated using the standard techniques for a linear model. There are two alternatives for this. One is to estimate the resultant equation using the non-linear estimation methods, which gives exactly identified coefficients if there is at least one explanatory variable in the model other than the profit variable. The other alternative is to incorporate the adaptive expectations into the model indirectly. For this, the above equation can be rewritten as (see for e.g., Kanwar, 2006).

$$\Pi^e_t = \Sigma^{\infty}_{\tau=1} \beta(1 - \beta)^{\tau} \Pi_{t-1-\tau} \qquad ....(7)$$

which can, under the conditions of stationarity and invertibility, be written as an ARMA (p,q) process

$$\Pi^e_t = \Sigma^{p}_{i=1} b_i \Pi_{t-i} + \Sigma^{q}_{j=0} c_j \mu_{t-j} \qquad ....(8)$$

where μ_t are white noise errors. More generally, if Π_t is integrated of order d, one can estimate an ARIMA(p,d,q) model. The fitted value $\hat{\Pi}_t$ from such a model then gives the expectation for the period t.

Rational and Quasi-Rational Expectations: The basic tenet of rational expectations hypothesis is that economic agents make purposeful and efficient use of information in optimising their decisions. Yet, in actual implementation, the general form of the rational expectations hypothesis is replaced by the implication that anticipated future values of relevant variables are equal to their expectations conditional on all past data and the model which describes the behaviour of this variable based on those expectations. Quasi-rational expectations are expectations obtained by relaxing some of the restrictions imposed by rational expectations. It can be shown that the quasi-rational expectations forecasts can be obtained by fitting an AR(I)MA model for the variable concerned (see, e.g., Nerlove and Bessler, 2001).

We consider incorporating expectations using three mechanisms (i) naïve expectations, (ii) extrapolative expectations, and (iii) adaptive expectations. Rational expectations, we feel, may not be justifiable on grounds of availability and processing of information for farmer's decision-making process, at least in a developing country like India where the literacy levels among the farmers are still not very high.

Incorporation of naïve expectations is straightforward: it simply involves including the first lag of the price variable as one variable in Z_t in Equation (3). Like the other coefficients, the coefficient of this lag divided by (1-coefficient of y_{t-1}) gives the long run elasticity of the dependent variable w.r.t. the price variable.

For extrapolative expectations, substituting for the expected price from Equation (5) into Equation (3) gives

$$y_t = (1 - \lambda)y_{t-1} + \lambda\phi[(1+\alpha)\Pi_{t-1} - \alpha\Pi_{t-2})] + \lambda\theta' Z_{1t} + \nu_t \qquad ....(9)$$

Where ϕ is the coefficient of the profit variable in the equation for the desired level of y_t and Z_1 is the vector of explanatory variables other than the profit variable. Thus having recovered the estimates of other coefficients in the manner described above, the parameter α can be recovered from the ratio of the coefficients of the two lags of Π_t.

The adaptive expectations can be incorporated using either the non-linear model or through the ARIMA model. However, given the small sample we have and large number of parameters, the estimation of the non-linear model is likely to encounter problems. Therefore, if needed, we explore the other alternative, viz., the ARIMA model. In order to obtain the expectations using ARIMA model, we use the standard time-series procedures described in standard time-series books on time series analysis (e.g., Enders, 2004). Again given the small sample we face severe problems in this type of estimation. Also, there are statistical issues about reliability of these forecasts with such a small sample. Therefore, other things remaining the same, we prefer the naïve expectations and extrapolative expectations over this mechanism, and try the adaptive expectations only if the two fail to give a satisfactory model.

Other Variables

Among the other factors, one needs to consider the enabling factors and the risk variables. Important enabling factors are water, rural public investment, etc. Water is an important input in agriculture, and there are two sources for this: rainfall and irrigation, and we consider both these factors. For rainfall, a number of variables have been used in the literature: quantum of total rainfall in a crop season, rainfall in pre-sowing period, absolute deviation from normal rainfall, etc. Similarly for indicator of irrigation facilities one can consider gross irrigated area or ratio of gross irrigated area to cropped area, among others. The other enabling factor is rural agricultural investment. Investment in the fields of irrigation, soil and water conservation, agricultural research and education, and storage and warehousing is expected to affect the acreage and other inputs favourably, since these factors reflect better infrastructure. Among the risk factors, the most important here is the price risk: too much variation in price may affect the desired input use by the farmer adversely.

We take two variables among all these: total rainfall and proportion of total land under irrigation, since the other factors do not seem that important here.

Role of Sugarcane Price Arrears

The factors discussed above are usually a part of any exercise in the estimation of agricultural response functions. However, unlike other agricultural commodities, expected sugarcane price (or sugar price) is not the only incentive variable in the case of sugarcane. Another variable is the quantum of cane price arrears.[1] Since this variable has not been taken into account in econometric studies conducted earlier by several scholars, it is necessary to show the manner in which it enters into the profitability calculus of the sugarcane farmer and affects his acreage decision.

The accumulation of cane price arrears is caused by excessive production of cane followed by that of sugar. This results in lower prices of sugar which reduces the total revenue of sugar factories. This, in turn, reduces the factories' viability and overall liquidity position, thereby increasing cane price arrears. These arrears have the effect of reducing the returns to the farmers and discourage them from cultivating cane in the following season. The resulting fall in cane production in the next year results in fall in production of sugar which eventually raises sugar prices as well as revenue of the factories. This is in sharp contrast with the prompt payment that the farmers get by selling any other produce like wheat, oilseeds, gram, soya bean, etc. They would naturally like to get prompt payment in the case of sugarcane also. This need for prompt cash becomes all the more clear once we note that sugarcane is grown mainly for sale and that the crop takes as long as one year for its maturity during which farmers are only incurring expenses.

Cane price arrears affect the farmers in other respects also. Excessive production of cane which is the cause of accumulation of price arrears, leads to cane-crushing capacity falling short of cane availability. This results in a lengthening of the crushing period, thereby forcing the farmers to wait up to the hot months of May or June for selling their produce to sugar factories. The consequent drying of cane juice results in loss of cane weight thereby forcing farmers to get less revenue, which acts as a disincentive to the farmers to grow cane. Moreover, accumulation of cane arrears also reduces financial resources of farmers because of which they are forced to spend less on use of inputs which results in lowering of yield. According to the Group of Experts mentioned above, "the main factor attributed to the cyclicality of sugar production in India is the cane price arrears".

This study, therefore, has included cane price arrears as another factor affecting production of sugarcane and its cyclicality. The effect through arrears on cane area can be regarded as an indirect effect of sugar price.

III

REVIEW OF LITERATURE

The response of supply to changes in output price in the Indian context with a focus on area has been a subject of study for a long time, e.g., Krishna (1962), Narain

(1965), Tyagi (1974), Ray (1980), Krishna and Roy Choudhari (1980), and Narayana and Parikh (1981), among others. Most of the past studies revealed weak supply response for Indian crops, thereby indicating dominance of non-price factors over price factors in farmers' decision making. This could be one reason for slackening of interest of researchers on this topic. This interest, however, was revived after the introduction of the policy of liberalisation. It was felt that supply response to price changes was likely to increase with the increasing liberalisation of the agricultural sector. The recent studies conducted on this subject might have been prompted by the need to throw light on this aspect. There is one more difference between the earlier and recent studies. While the earlier studies concentrated on food grains, mainly paddy and wheat, the recent studies have a much wider coverage with several cash crops including sugarcane. The recent studies, which also take care of the prevailing post-liberalisation economic scenario, are most relevant in our present context. One can identify at least three recent studies which study the supply response function for sugarcane using data for the post-liberalisation period. These are Mythili (2007), Kanwar and Sadoulet (2008) and Bathla (2009).

Mythili (2007) studied the response of area and yield to price, allowing for effect of reforms using panel data from Indian states for the period 1970-71 to 1999-2000. This study used data for all states contributing 4 per cent or more to total national output for each crop, and thus used the following states for sugarcane: Andhra Pradesh, Karnataka, Tamil Nadu, Gujarat, Maharashtra and Uttar Pradesh. The author estimated a single equation for rice and sugarcane and found significant price response by both area and yield in case of sugarcane. For price variable, the author used the farm harvest price. The study found significant response of area under these crops to total rainfall and yield to per cent absolute deviation from normal rainfall. The study then estimated the price elasticities for each crop using dynamic panel data model estimated using Arellano and Bond (1991) estimator.

Kanwar and Sadoulet (2008) estimated agricultural response functions for major crops including sugarcane for India for the period 1967-68 to 1999-2000 using panel data covering major states contributing to production of respective crops. The study used the quasi-rational expectations formulation of the adaptive expectations for relative profitability in the framework of partial adjustment and estimated the equations using the Arellano-Bond estimator. The study allowed for explicit structural change in 1986. It was found that, in the pre-1986 period, the area under sugarcane was affected by its relative profitability, yield, risk and irrigation. Post-1986, the effect of both relative profitability and yield risk went up. The yield was affected, pre-1986 by price-risk. Post–1986, the effect of infrastructure was also significant. Though in some cases the sowing season rainfall is also significant, the coefficients are too small and negative, which the authors dismiss as being unimportant given the fact that more than 90 per cent of area under sugarcane is irrigated, leaving very little dependence on rainfall. For both area and yield the lagged dependent variable is significant.

Bathla (2009) estimates a structural time series macroeconometric model for six crops individually, sugarcane being one of them. The period of the study is 1980-81 to 2002-03 and the equations are estimated using both OLS and TSLS, allowing for possible autocorrelation. The results show that the area under sugarcane is affected by own price and competing crop price, in addition to its own lag. The yield on the other hand is affected by rainfall, irrigation and technology.

This discussion makes it clear that the existing studies on agricultural response of sugarcane cover period at the most up to 2002-03. These studies use panel data. Further these studies do not consider the role that of sugarcane price arrears. We attempt to contribute to the existing literature by incorporating the latest data, and also by studying the possible role that the sugarcane price arrears play in the decision of the farmer.

IV

DATA AND METHODOLOGY

We estimate the supply response of sugarcane in terms of both area and yield. This is done in the framework of partial adjustment model, thus allowing for slow adjustment towards the desired values. This is done for All-India and also for the two most important sugarcane producing states, Uttar Pradesh and Maharashtra, using annual data for the period 1990-91 to 2009-10. For profit variable we take three indicators: price of sugarcane, price of sugarcane relative to wheat, and the price of sugar. It is realised that in the areas where sugarcane is sown, wheat is the only substitute for sugar, if at all. Finally, we also consider the price of sugar which farmers take into account carefully since sugarcane production is meant mainly for sugar mills. As discussed above, the wholesale price is not a good indicator of the price reaching the hands of the farmer. Therefore, for the price of sugarcane we take two variables: the minimum support price, and the state-administered price or the farm-harvest price. We model the expectations using the naïve expectations and the extrapolative expectations as far as possible, since the short data series do not allow us to estimate the adaptive expectations reliably. As discussed above, in case of sugarcane, an additional important factor is sugarcane price arrears. One aspect in which this paper improves upon the existing literature is in examining explicitly the role of sugarcane price arrears in the decision-making of farmers. However, non-availability of reliable data did not permit us to do this for state-level analysis. Finally we consider two variables measuring availability of water for crops: (i) rainfall and (ii) proportion of irrigated area to total area under the crop. Non-availability of data did not permit us to include the factors like consumption of electricity, fertilisers, pesticides, etc. for sugarcane. The data were collected from various publications of the Government of India.

V

DISCUSSION OF RESULTS

The estimation results are given in Tables 1 to 9. All the models were tested for residual autocorrelation using the LM test and also for normality of residuals. Only the models clearing mis-specification checks are being given here. The variable acronyms are as follows: A stands for area, Y for yield, SP sugar price and R for rainfall. 'I' at the end of an acronym indicates All-India; 'U' indicates Uttar Pradesh and 'M' indicates Maharashtra. For instance, YM indicates yield for Maharashtra, while AI indicates Area All India. With the naïve and extrapolative expectations, adjustment parameter is simply equal to (1-*coefficient of the lagged dependent variable*).

5.1 *All India*

For area under sugarcane for All India, the equation with sugar prices with extrapolative expectations gives the best results (Table 1). This equation explains about 70 per cent of total variation in total area under sugarcane. Therefore, it can be said that the variation in area under sugarcane is driven mainly by the market price of sugar. The coefficient of lagged area is about 0.42, which gives an adjustment coefficient of 0.5 approximately. Further, the elasticity of area with respect to sugar prices comes out to be 0.51.

TABLE 1. AREA FOR ALL INDIA

DEPENDENT VARIABLE: AI

Variable (1)	Coefficient (2)	Prob. (3)
C	3.374205	0.1216
AI(-1)	0.422504	0.1456
SPI(-1)	0.544280	0.0461
SPI(-2)	-0.248952	0.3620
R-squared		0.710696
Adjusted R-squared		0.648703
Prob (F-statistic)		0.000460

The variable acronyms are as follows: A stands for area, Y for yield, SP for sugar price, CA for cane arrears and R for rainfall. 'I' at the end of an acronym indicates All India; 'U' indicates UP and 'M' indicates Maharashtra. For instance, YM indicates yield for Maharashtra, while AI indicates Area All India. With the naïve and extrapolative expectations, adjustment parameter is simply equal to (1-coefficient of the lagged dependent variable).

For yield, the equation with the first lag of rainfall but without any price variable clears all the misspecification tests. It shows that the adjustment coefficient is close to 0.75, showing quite fast adjustment. This equation explains approximately 50 per cent of total variation in yield as shown by R^2, and highlights the importance of rainfall in determining the use of inputs other than area.

TABLE 2. YIELD FOR ALL INDIA

DEPENDENT VARIABLE: YI

Variable (1)	Coefficient (2)	Prob. (3)
C	5.844000	0.0089
YI(-1)	0.277634	0.1723
RI(-1)	0.309096	0.0140
R-squared		0.496229
Adjusted R-squared		0.433258
Prob (F-statistic)		0.004148

As discussed in the previous section, in the case of sugarcane it is the cane price arrears that matters more than the actual price, due to the lags in payment to the farmers. While it was not possible to get reliable data for all years for this variable for the individual states, we have tried this variable for All India. The estimation results, given in Tables 3 and 4 for area and yield respectively, suggest that this variable has high explanatory power for all India. The jump in the value of adjusted R^2 from 0.64 to 0.85 for area and 0.43 to 0.51 for yield highlights the key role of the cane price arrears in the farmer's decision-making process for sugarcane production.

TABLE 3. AREA FOR ALL INDIA, WITH SUGARCANE PRICE ARREARS

DEPENDENT VARIABLE: AI

Variable (1)	Coefficient (2)	Prob. (3)
C	6.361340	0.0000
CAI(-2)+CAI(-3)	-0.010053	0.0002
SPI(-1)	0.425640	0.0000
R-squared		0.873119
Adjusted R-squared		0.854993
Prob (F-statistic)		0.000001

TABLE 4. YIELD FOR ALL INDIA, WITH SUGARCANE PRICE ARREARS

DEPENDENT VARIABLE: YI

Variable (1)	Coefficient (2)	Prob. (3)
C	6.282380	0.0034
YI(-1)	0.437800	0.0172
CAI(-1)	-0.008183	0.0038
R-squared		0.565950
Adjusted R-squared		0.511693
Prob (F-statistic)		0.001260

5.2 *Uttar Pradesh*

For Uttar Pradesh, the area is found to be dependent on the sugar price. The model (given in Table 5) with the naïve expectations of this price variable is found to be better than the other options. The coefficient of the lagged dependent term is below 0.25, indicating that the adjustment coefficient is more than 0.75. This coefficient is statistically insignificant even at 25 per cent level of significance, which means that we cannot reject the hypothesis that the adjustment coefficient is 1. The model without the partial adjustment performs no worse than this confirming no adjustment lags for this variable. These results are also given in Table 6 and show that the elasticity of area with respect to sugar prices is 0.19. This equation explains approximately 56 per cent of total variation in area.

TABLE 5. AREA FOR UTTAR PRADESH

DEPENDENT VARIABLE: AU

Variable (1)	Coefficient (2)	Prob. (3)
C	4.723108	0.0034
AU(-1)	0.242850	0.2728
SPU(-1)	0.143386	0.0205
R-squared		0.592706
Adjusted R-squared		0.541794
Prob (F-statistic)		0.000757

TABLE 6. AREA FOR UTTAR PRADESH, WITHOUT PARTIAL ADJUSTMENT

DEPENDENT VARIABLE: AU

Variable (1)	Coefficient (2)	Prob. (3)
C	6.250258	0.0000
SPU(-1)	0.187532	0.0002
R-squared		0.559878
Adjusted R-squared		0.533989
Prob (F-statistic)		0.000229

The yield, on the other hand, depends only on rainfall and does not depend on any measure of profitability, as in case of All India. While this may appear surprising, it may be due to the fact that several other factors, possibly several exogenous shocks like plant diseases and pest attacks, weather, availability of electricity, etc., have dominated the effect of price variable during the period of study. This is to some extent corroborated by the low values of R-squared and adjusted R-squared.

TABLE 7. YIELD FOR UTTAR PRADESH

DEPENDENT VARIABLE: YU

Variable (1)	Coefficient (2)	Prob. (3)
C	5.934916	0.0246
YU(-1)	0.389371	0.0854
RU(-1)	0.113524	0.0513
R-squared		0.307306
Adjusted R-squared		0.220719
Prob (F-statistic)		0.053007

5.3 *Maharashtra*

For Maharashtra, the equation with naïve expectations of sugar prices is found to perform the best. It shows an adjustment coefficient of about 0.63. The elasticity of area with respect to sugar prices is 1.13. The results show that sugar prices and rainfall taken together explain about 84 per cent of total variation in area. Unlike All-India and Uttar Pradesh, here the equation with sugar prices only showed significant autocorrelation in residuals, and this autocorrelation vanished once lagged rainfall was included. The coefficient of rainfall is highly significant, showing the important role it plays in farmers' decision-making about area. This is further reflected in the value of R^2 which jumps from 0.63 to 0.84 on inclusion of the lagged rainfall term. The yield is found to be dependent only on the rainfall, like All India and Uttar Pradesh.

TABLE 8. AREA FOR MAHARASHTRA

DEPENDENT VARIABLE: AM

Variable (1)	Coefficient (2)	Prob. (3)
C	-7.447383	0.0005
AM(-1)	0.376626	0.0060
SPM(-1)	0.701553	0.0004
RM(-1)	0.925308	0.0004
R-squared		0.844553
Adjusted R-squared		0.813464
Prob (F-statistic)		0.000003

TABLE 9. YIELD FOR MAHARASHTRA

DEPENDENT VARIABLE: YM

Variable (1)	Coefficient (2)	Prob. (3)
C	5.009596	0.0173
YM(-1)	0.360007	0.0797
RM(-1)	0.320452	0.0249
R-squared		0.543432
Adjusted R-squared		0.486361
Prob (F-statistic)		0.001888

5.4 *Summing Up*

The estimation results clearly highlight the role of both price and non-price factors in sugarcane production at All-India level as well as at state level. The area is found to be affected mainly by sugar prices in All-India and Uttar Pradesh but in Maharashtra the rainfall is also found to be an important factor.

The elasticity of area with respect to sugar prices is very low (0.19) in Uttar Pradesh and very high (1.13) in Maharashtra. The tests show that while the elasticity in Uttar Pradesh is significantly less than 1, that in Maharashtra is not significantly different from 1. Thus we find sharp differences between these two states in terms of responsiveness of area to sugar prices: while in Uttar Pradesh one per cent change in sugar prices causes the area to change by much less than one per cent, in Maharashtra one per cent change in sugar prices causes area to change by one per cent approximately. The elasticity for All-India is, as expected, between these two values (0.51).

The yield, on the other hand, is found to be affected only by rainfall, at All-India level as well as in the two individual states studied here. Further, the part of total variation our equations have been able to explain is much lower for yield than for area (0.50 as compared to 0.71 for All-India, 0.31 as compared to 0.56 for Uttar Pradesh and 0.54 as compared to 0.84 for Maharashtra). This highlights the fact that the non-price factors are more important than price factors in the farmers' decisions about inputs other than area.

Finally we find that sugarcane price arrears have a very high explanatory power for area as well as yield. Inclusion of cane price arrears raises the value of R^2 from 0.71 to 0.87 in case of area and 0.50 to 0.57 in case of yield. The fact that even here R^2 is low for yield as compared to area re-emphasises the role of non-price factors in inputs other than area. However, non-availability of data prevented us from studying the impact of cane arrears on cane production at the state level.

VI

CONCLUSIONS

This paper attempts to study the factors responsible for fluctuations in the production of sugarcane, the most important input for the production of sugar. The supply response functions for sugarcane are estimated for All India as well as Uttar Pradesh and Maharashtra, the two most important states of India with respect to the production of sugarcane. The results suggest that the area under cane is affected mainly by sugar prices during last one or two years. In addition to sugar prices, rainfall too affects the production, and this effect comes through factors other than area. The high explanatory power of cane arrears with requisite sign underlines the important role of payment practices in determining cane production. Finally, the equations for yield have low values of adjusted R^2 indicating the important role played by non-price factors, e.g., pest attacks, climatic factors etc. One can explain the variation in yield better if the quality data are available for these factors.

Received July 2012. *Accepted November 2012.*

NOTE

1. Attention to the important role of this variable has been drawn earlier by the reports of the Commission of Agricultural Costs and Prices (CACP), Government of India in 2001 and 2009-10. The Report of the High Powered Committee on Sugar Industry (April 1998 – Chairman B.B. Mahajan) had regarded the accumulation of arrears of cane payments, during the previous year, as one of the key

factors which leads farmers to reduce area under cane. The March 2009 Report of the Group of Experts too has laid emphasis on the effect of cane price arrears in producing a significant fall in area under sugarcane. During our field surveys in both Maharashtra and Uttar Pradesh, it was found that farmers laid great emphasis on this factor.

REFERENCES

Arellano, M. and Stephen Bond (1991), "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations", *The Review of Economic Studies*, Vol.58, No.2, pp.277-297.

Bathla, Seema (2009), "Macroeconomic Policies and Agriculture Supply Response in India: A Commodity Level Analysis", *The Indian Economic Journal*, Vol.57, No.2, pp.97-125.

Enders, W. (2004), *Applied Econometric Time Series*, Wiley.

Kanwar, S. (2006), "Relative Profitability, Supply Shifters and Dynamic Output Response, in a Developing Economy", *Journal of Policy Modeling*, Vol.28, Pp.67-88.

Kanwar, Sunil and Elisabeth Sadoulet (2008), "Dynamic Output Response Revisited: The Indian Cash Crops", *The Developing Economies*, Vol.46, No.3, pp.217-241.

Krishna, Raj (1962), "A Note on the Elasticity of the Marketable Surplus of a Subsistence Crop", *Indian Journal of Agricultural Economics*, Vol.17, No.3, July-September, pp.79-84.

Krishna, Raj and Gauri S. Raychaudhuri (1980), *Some Aspects of Wheat and Rice Price Policy in India,* World Bank Staff Working Paper No.381, The World Bank, Washington, D.C., U.S.A.

Maddala, G.S. (2002), *Introduction to Econometrics*, Third Edition, Wiley, Singapore.

Mythili, G. (2007), "Supply Response for Major Crops in the Pre-Reform Periods: A Dynamic Panel Data Approach", *Journal of Quantitative Economics*, Vol.5, No.1, pp.65-84.

Narain, Dharm (1965), *The Impact of Price Movements on Areas Under Selected Crops in India 1900-1939*, Cambridge University Press, Cambridge.

Narayana, N.S.S. and Kirit S. Parikh (1981), *Estimation of Farm Supply Response and Acreage Allocation,* IIASA Research Report No.RR-81-001, International Institute of Applied Systems Analysis, Laxenburg.

Nerlove, M. (1958), *The Dynamics of Supply: Estimation of Farm Supply Response to Price*, The Johns Hopkins University Press, Baltimore.

Nerlove, M. and D.A. Bessler (2001), "Expectations, Information and Dynamics" in B. Gardner and G. Rausser (Eds.)(2001), *Handbook of Agricultural Economics*, Vol.1 (Elsevier Science BV), pp.155-206.

Ray, Susanto K. (1980), "Weather, Prices and Fluctuations in Agricultural Production", *Indian Economic Review*, Vol.16, No.4, pp.251-77.

Tyagi, D.S. (1974), *Farmers' Response to Agricultural Prices in India: A Study in Decision Making*, Heritage Publishers, Delhi.