Vol XLVI
No. 4

OCTOBER-
DECEMBER
1991

ISSN 0019-5014

INDIAN JOURNAL OF AGRICULTURAL ECONOMICS

INDIAN SOCIETY OF
AGRICULTURAL ECONOMICS,
BOMBAY

Ind. Jn. of Agri. Econ.
Vol. 46, No. 4, Oct.-Dec. 1991

Dynamics of Increasing Potato Acreage in Uttar Pradesh: An Inter-Regional Analysis of Farmers' Response

The objective of this paper is to explain the changes in potato acreage of Uttar Pradesh which has recorded a relatively higher increase in the production of this crop compared to other major potato growing states of India. This concern arose because the phenomenal growth in potato production since the late fifties has also been accompanied by its increasing concentration in some states and the resultant problems of marketing. The study attempts to explain the acreage allocation behaviour of potato cultivators in terms of their responsiveness to price and non-price factors over the period, 1955-56 to 1982-83. Specifically, the study estimates the elasticities of potato acreage in Uttar Pradesh and its sub-regions with respect to the crop's *(i)* farm harvest price, *(ii)* yield and *(iii)* risk variables arising from price and yield. The estimation procedure basically relies on Marc Nerlove's (1958) partial adjustment adaptive expectational (PAAE) model. The model has also been estimated with first-differences of the variables which helped us to investigate the appropriate measure for risk factors. Besides, the model has enabled us through its adjustment coefficient to estimate the degree of farmers' realisation of various incentives available to them.

Section I of the paper gives an overview of potato production in India and the relative position of the State of Uttar Pradesh which is selected for the analysis. Section II deals with the model adopted for estimation. Section III discusses the results and Section IV presents the conclusions.

I

SELECTION OF THE CROP AND THE STATE

Potato is one of the four important crops (other crops are paddy, wheat and sugarcane) which contributed to an impressive increase in agricultural output especially during the seventies.[1] Potato acreage increased at an annual compound growth rate of 3.89 per cent during 1955-82, compared to the growth rate of 0.60 per cent for all crops and 2.41, 2.29 and 1.61 per cent for wheat, sugarcane and paddy respectively. The estimates of acreage supply equations for the crops like wheat, paddy and sugarcane have indicated that the farmers were influenced by the higher profitability of these crops while allocating acreage under them (Sangwan, 1985). Some such studies for potato in Britain (Insergent, 1969; Revell 1974) also indicate positive relation between potato acreage and its price or returns, though it was relatively weak. However, in India, it is the first attempt to extend this analysis to potato,[2] the production of which has increased at a compound growth rate of 5.31 per cent per annum, the highest of all individual crops, during 1955-82.

Although potato is cultivated throughout India,[3] the State of Uttar Pradesh was selected for the analysis as it accounted for about 44 and 38 per cent of all-India potato production and acreage respectively and exhibited a response pattern similar to the national trend. The rapid increase in the all-India potato acreage was accompanied by an increase in the share of the state from 30.86 per cent during 1960-63 to 38.26 per cent during 1983-86. The selection of one state is also convenient for identifying the competing crop out of a few important crops cultivated in this region. Potato is mainly cultivated in the *rabi* season and under assured irrigation conditions in this state which further reduced the number of competing crops.[4] Moreover, confining the study to one state enabled us to estimate and compare the responsiveness of farmers at the micro level.

Uttar Pradesh with an area of 294 thousand square kilometres, is itself a big region to be considered homogeneous. Besides, the agro-climatic factors, the market infrastructure, the size of holdings and extension services vary over the state. In view of these differences in the motivating conditions and cropping pattern, the acreage response functions have also been estimated for seven sub-regions of the state. These sub-regions were carved out of the 26 important potato growing districts[5] of Uttar Pradesh. Most of these districts are situated along both sides of the river Ganga and its tributaries. These districts have been grouped into following sub-regions on the basis of similarity in their cropping pattern.

Sub-region	Districts included	First four major crops in descending order (triennium ending 1981-82)
I.	Mainpuri, Farrukhabad Etawah, Kanpur, Hardoi and Lucknow.	Wheat, rice, maize, gram.
II.	Meerut (including Gaziabad) and Bulandshahr.	Wheat, sugarcane, gram, maize.
III.	Moradabad, Rampur, Badaun, Shahjahanpur and Etah.	Wheat, rice, sugarcane, maize.
IV.	Faizabad, Sultanpur, Pratapgarh and Jaunpur.	Rice, wheat, gram, maize.
V.	Fatehpur, Allahabad, Rai-Bareilly and Barabanki.	Wheat, rice, gram, sugarcane.
VI.	Azamgarh, Ballia, Ghazipur and Varanasi.	Wheat, rice, gram, sugarcane.
VII.	Gorakhpur.	Rice, wheat, sugarcane, gram.

These sub-regions also differ in terms of their distance from agricultural universities, potato seed farms and consumption markets of the crop. Hence, estimation of acreage supply response for each of the sub-regions may be interesting for future strategy of planning acreage under potato.

II

METHODOLOGY

A. The Model

To study the supply response behaviour of potato cultivators, the frequently and extensively used Nerlovian PAAE Model (Askari and Cummings, 1977) has been considered appropriate (Jennings and Young, 1980) to develop the analytical framework. The exact form of the estimating equation, obtained by substitution between long-run adaptive supply equation and the partial adjustment equation, is as follows:

$$A_t = b_0+b_1 P_{t-1} + b_2Y_{t-1} + b_3 CV_p + b_4 CV_y + b_5 A_{t-1} + b_6 A_{t-2} + V_t \qquad .... (1)$$

where $b_0 = a_0 B\phi$, $b_1 = a_1 B\phi$, $b_2 = a_2 B\phi$, $b_3 = a_3 B\phi$, $b_4 = a_4 B\phi$, $b_5 = (1-B) + (1-\phi)$, $b_6 = -(1-B)-(1-\phi)$, and $V_t = U_t-(1-\phi) U_{t-1}$ in which a_0, a_1, a_2......... are the coefficients of long-run supply equation and B and ϕ are coefficients of adjustment and adaptation respectively. Usually, ϕ is assumed one, taking the last year's price as the expected price of this year, but we have done away with this asumption to assess the effect of including A_{t-2}. The parameters B and ϕ enter symmetrically in this equation, hence their values will be computed by finding the values of $(B+\phi)$ and $B\phi$.

The variables are denoted as follows:

A_t = area actually planted under potato,
t = always refers to t-th production period,
P_{t-1} = the ratio of farm harvest price of potato with respect to competing crop which will henceforth be called relative price. Wheat was selected as competing crop for potato, keeping in view the nature of requirements of irrigation and other inputs in the same season.
Y_{t-1} = the ratio of the yield of potato to the yield of wheat,
CV_p = coefficient of variations of the relative prices of potato for the years t-1, t-2 and t-3, used as a measure of price risk,
CV_y = coefficient of variations of the relative yield of potato for the years t-1, t-2 and t-3, used as a measure of yield risk.

The variables like irrigated area and rainfall have been considered redundant after verification from the trends of their time-series (Sangwan, 1987). This stems from the fact that irrigation is an essential pre-requisite for cultivation of potato in this state. Model (1) has also been estimated with absolute form of the above variables to assess the responsiveness with different concepts of the same variable. Even equations with relative returns (Y × P) and absolute returns were estimated to assess the combined responsiveness to these variables; however, these results are not presented in this paper.

B. Model Using First-Differences of Time-Series

Nearly all the economic time-series possess significant trend and hence their error term, in general, violates the essential condition of stationarity[6] for absence of auto-correlation. It is suggested that a model with first-differences not only introduces stationarity in the applied set of series but it is also more plausible as it analyses the dynamics of the phenomenon (Nelson and Kangle, 1981). Hence, along with model (1) using level of time-series, the following model using first-difference of the variables was also applied.[7]

Subtracting from equation (1) for A_t, a similar equation for A_{t-1}, the estimating equation with first-difference is as follows:

$$a_t = t_0 + b_1 p_{t-1} + b_2 y_{t-1} + B_3 cv_p + b_4 cv_y + b_5 a_{t-1} + b_5 a_{t-2} + \xi_t \quad .... (2)$$

where t_0 is a constant term for implicit time variable. But even after transformation, the coefficients of independent variables remain unchanged, though the new disturbance term is:

$$\xi_t = V_t - V_{t-1} = (U_t - U_{t-1}) - (1-\phi)(U_{t-1} - U_{t-2})$$

This error term may be serially independent and normally distributed being drived from the error terms of the residuals.

The notations of variables in small letters are the first-differences of variables in model (1), *e.g.*,

$a_t = A_t - A_{t-1}$, $p_{t-1} = P_{t-1} - P_{t-2}$, $y_t = Y_{t-1} - Y_{t-2}$ and so on.

Model (2) was also estimated with absolute concepts of these variables as well as both the absolute and relative concepts of profitability (returns). Thus four equations of each region were estimated with model (2) too. Hence, eight equations were estimated for each region to assess the responsiveness to different concepts of included variables; however, only four equations are presented for each region to economise on space.

Inclusion of p_{t-1} and A_{t-1} as well as A_{t-1} and A_{t-2} may cause the problem of serial correlation and multicollinearity. Serial correlation has been tested by computing Durbin's (1970) h-statistics. Multicollinearity has been considered harmful if simple correlation between any two variables is greater than overall (multiple) correlation of the relationship (Klein, 1976). Moreover, the equations were estimated by gradually including the additional variables one by one in the relationship and judging their importance by using, among others, as criteria their standard errors. Thus all the variables may not appear in the estimated equations in spite of their provision in the model.

C. Data Source

Potato acreage relates to area cultivated under both its early and main crops. Time-series data of potato and the competing crop wheat for the study were collected from the publications of the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India and various departments of the Government of Uttar Pradesh.[8] The post-harvest prices at district level after 1978-79 were collected from unpublished records of the Department of Revenue, Government of Uttar Pradesh.

III

RESULTS AND DISCUSSION

Supply equations for levels and first-differences of potato acreage based on twenty-four and twenty-three time-series observations respectively are presented in Tables I and II. The twenty-four observations relate to acreage planted during 1958-59 to 1982-83 as the three initial years, *i.e.*, 1955-56 to 1957-58 are lost in taking the lagged values of some variables. In the case of equations with first-differences, one more observation is reduced, thus confining the period to the years 1959-60 to 1982-83.

All the estimated equations are in simple linear form and show good fit to the data. The coefficient of adjusted multiple correlation ($\bar{R}^2$) is above 0.8 in almost all equations, explaining the acreage under potato (Table I). In the case of equations for explaining changes in acreage planted under potato (Table II) as *a priori* expectation, the values of $\bar{R}^2$ are lower, ranging between 0.20 and 0.70 in most of the equations and it did not turn out significant at all in sub-region II. Durbin's (1970) h-statistics has not indicated serial correlation in most of the equations.[9] Going by Klein's (1976) thumb rule, multicollinearity is not detected among the variables included in the estimated equations. The short-run elasticities of potato acreage with respect to price and yield were computed[10] from the results of Tables I and II and these are presented in Table III along with the coefficient of adjustment. The main results of the study are discussed here.

TABLE I. ESTIMATED FUNCTIONS EXPLAINING POTATO ACREAGE IN UTTAR PRADESH AND SUB-REGIONS, 1958-83

State/ Sub-region		Variables							$\bar{R}^2$ (F-value)
		Cons-tant	P_{t-1}	Y_{t-1}	CV_P	CV_Y	A_{t-1}	A_{t-2}	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Entire state	R	-70.67	123.95	4.09	-	-	0.69	0.28	0.82
		(NC)	(2.94)*	(1.22)			(3.31)*	(1.41)	(43.99)
	A	14.00	1.48	0.46	-	-	0.41	-	0.96
		(NC)	(7.78)*	(2.73)†			(3.63)*		(156.75)
Sub-region I	R	-98.20	338.94	-	-	-	1.00	-	0.88
		(1.77)	(3.19)*				(12.60)*		(86.92)
	A	-2.49	4.27	0.98	-	-	0.57	-	0.95
		(0.03)	(7.04)*	(1.83)			(5.11)*		(155.36)
Sub-region II	R	-3.87	-	-	-	-	0.70	0.44	0.93
		(0.13)					(8.42)	(1.86)	(155.80)
	A	-12.38	0.46	0.33	-	-	0.69	-	0.94
		(0.56)	(2.37)†	(2.10)†			(4.56)*		(129.57)
Sub-region III	R	-133.16	228.89	7.49	-	-	0.88	-	0.81
		(3.29)*	(4.35)*	(2.40)†			(8.42)*		(33.69)
	A	11.52	1.80	1.17	-	-	-	-	0.87
		(0.55)	(5.59)*	(6.57)*					(78.46)
Sub-region IV	R	2.98	-	-	-	-	0.54	0.51	0.92
		(0.05)					(2.44)†	(2.24)†	(130.74)
	A	-1.30	0.97	0.33	-	-	0.38	0.34	0.94
		(0.07)	(2.82)*	(1.69)			(1.82)	(1.68)	(92.06)
Sub-region V	R	134.16	297.02	12.38	-	-	0.49	-	0.58
		(2.34)†	(3.22)*	(3.11)*			(3.53)*		(11.45)
	A	36.04	2.30	0.67	-	-	-	-	0.79
		(1.10)	(4.17)*	(2.58)†					(44.28)
Sub-region VI	R	-24.44	95.67	-	-	-	0.96	-	0.86
		(1.33)	(2.69)†				(11.81)*		(75.90)
	A	20.46	1.25	-	-	-	0.62	-	0.93
		(1.39)	(5.80)*				(7.34)*		(152.28)
Sub-region VII	R	-0.03	-	-	-	-	0.80	-	0.92
		(0.01)					(11.73)*		(125.11)
	A	1.35	0.26	0.07	-	-	0.47	0.16	0.95
		(0.33)	(3.63)*	(2.19)†			(5.06)*	(6.62)*	(114.97)

Notes:- Figures in parentheses are t-ratios.
NC means not computed.
R = Equations using relative price and yield of potato with respect to those of wheat.
A = Equations using absolute price and yield of potato.
* Significant at 99 per cent level of confidence.
† Significant at 95 per cent level of confidence.

A. Price Response

Column (4) of Table I shows that both the concepts of price, *viz.*, relative price with respect to competing crop wheat and absolute price of potato, bear positive and significant relation with the acreage of the crop in almost all the sub-regions and the state as whole. However, the relation with absolute price has turned out significant in more of the sub-regions compared to that of relative price.[11] Almost similar association between changes in potato acreage and that of prices is discernible from column (4) of Table II, though in less number of equations.

TABLE II. ESTIMATED FUNCTIONS EXPLAINING POTATO ACREAGE IN UTTAR PRADESH AND SUB-REGIONS, 1959-83

State/ Sub-region		Variables							$\bar{R}^2$
		Cons-tant	p_{t-1}	y_{t-1}	CV_p	CV_Y	a_{t-1}	a_{t-2}	(F-value)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Entire state	R	15.72	1.55	0.82	-	-0.82	-0.40	-0.37	0.37
		NC	(1.29)	(2.23)†		(1.39)	(1.40)	(1.53)	(19.69)
	A	9.03	1.07	0.84	-	-0.79	-	-0.25	0.461
		NC	(4.01)*	(2.99)*		(1.44)		(1.24)	(5.12)
Sub-region I	R	34.03	216.77	-	-2.66	-	-	-0.38	0.35
		(2.59)†	(2.75)†		(3.02)*			(2.04)†	(4.54)
	A	11.80	3.36	2.43	-	-5.20	-	-	-
		(1.09)	(4.73)*	(3.65)*		(2.42)†			
Sub-region II	R, A	Equation was not significant in explaining variations.							
Sub-region III	R	21.66	-	-	-1.57	-	-0.61	0.64	0.57
		(3.89)*			(3.03)*		(3.56)*	(3.84)*	(10.88)
	A	5.75	1.80	0.93	-	-	-	-0.47	0.45
		(0.94)	(4.33)*	(2.40)†				(2.67)†	(7.07)
Sub-region IV	R	17.58	-	-	-	-	-0.65	-8.52	0.28
		(4.27)*					(2.96)*	(2.30)*	(5.29)
	A	17.58	-	-	-	-	0.65	-0.52	0.28
		(4.27)*					(2.96)*	(2.30)†	(5.24)
Sub-region V	R	8.70	134.76	-	-1.63	-	-	-	0.70
		(2.76)†	(4.49)*		(5.94)*				(27.16)
	A	13.63	-	-	-	-	-0.51	-	0.23
		(2.52)†					(2.70)†		(7.30)
Sub-region VI	R	6.06	60.11	-	-	-	-	-	0.20
		(1.85)	(2.56)†						(6.35)
	A	4.32	0.90	-	-	-	-	-	0.42
		(1.53)	(4.14)						(17.13)
Sub-region VII	R, A	Equation was not significant in explaining variations.							

Notes:- $p_{t-1} = P_{t-1} - P_{t-2}$, $y_{t-1} = Y_{t-1} - Y_{t-2}$, $a_{t-1} = A_{t-1} - A_{t-2}$ and $a_{t-2} = A_{t-2} - A_{t-3}$.

The extent of responsiveness of potato cultivation to price in terms of price elasticities of potato acreage is shown in columns (4) and (7) of Table III. The elasticity of potato acreage in Uttar Pradesh as a whole with respect to the four alternative concepts of price lies between 0.28 and 0.49 and all of them are significant at the 90 per cent level of confidence. Over the sub-regions, the elasticity with respect to absolute price varies from 0.16 to 0.43. The elasticities with respect to relative price and changes in absolute price for different sub-regions are also quite comparable in level of significance and their magnitudes are also in a close range with that of absolute price but the elasticities with first-differences are quite low in some sub-regions.

Among the sub-regions, the price elasticities, in general, are relatively higher in sub-regions III and V and lower in sub-regions II, IV and VII. The districts covered under sub-regions III and V have relatively benefited more from the infrastructural facilities during the study period from a very low base. On the other hand, sub-regions IV and VII have relatively more small cultivators, lesser number of agricultural markets and poor transport network (Sangwan, 1987). In the case of sub-region II comprising Meerut and Bulandshahr, the price has recorded a relatively smooth increase over the period due to its closeness with Delhi market and better links with other markets. The potato acreage of the remaining sub-regions showed medium responsiveness to price variations.

TABLE III. COEFFICIENT OF ADJUSTMENT AND SHORT-RUN ELASTICITIES OF POTATO ACREAGE IN UTTAR PRADESH AND ITS SUB-REGIONS

State/ Sub-regions		In the equations of levels (Table I)			In the equations of first-differences (Table II)		
		Coefficient of adjustment	Elasticity of A_t with respect to		Coefficient of adjustment	Elasticity of (A_t-A_{t-1}) with respect to	
			P_{t-1}	Y_{t-1}		P_{t-1}	Y_{t-1}
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Entire state	R	0.31	0.33*	0.20	ND	0.33†	0.33*
	A	0.59	0.28*	0.25†	0.50	0.49*	0.63*
Sub-region I	R	0.02	0.25*	-	ND	0.20†	-
	A	0.43	0.27*	0.20	1.00	0.26*	0.41*
Sub-region II	R	0.10	-	-	-	-	-
	A	0.31	0.16†	0.32†	-	-	-
Sub-region III	R	0.12	0.52*	0.37†	-	-	-
	A	1.00	0.32*	0.62*	0.31	0.34*	0.23*
Sub-region IV	R	-0.04	-	-	-	-	-
	A	0.62	0.17†	-	-	-	-
Sub-region V	R	0.51	0.60*	0.70*	1.00	0.06*	-
	A	1.00	0.43*	0.37†	-	-	-
Sub-region VI	R	0.04*	0.23*	-	1.00	0.05*	-
	A	0.38	0.28*	-	1.00	0.32	-
Sub-region VII	R	0.08	-	-	-	-	-
	A	0.29	0.22*	0.15†	-	-	-

Notes:- 1. The short-run elasticity of acreage with respect to independent variable, *i.e.*, $(DA/dx)(\bar{X}/\bar{A})$, where x is independent variable, was calculated by multiplying the coefficient of each independent variable with the ratio of average of that variable and area over the period of study. The long-run elasticity may be obtained by dividing short-run elasticity by the respective coefficient of adjustment.

2. The coefficients of A_{t-1} and their first-differences were used to work out B, ϕ, indirectly.

ND = Values not defined due to negative values of factors whose under root was to be taken.

Footnotes as in Tables I and II.

Comparison of these elasticities with that of other crops (Sangwan, 1985) indicated that farmers are more conscious of price while allocating acreage under potato vis-a-vis foodgrain crops. Thus the relative higher and significant responsiveness to prices has been one of the factors which helped to increase the acreage under this crop, though its importance was not equal in all the sub-regions of the state.

B. Yield Response

Potato acreage of the entire state has positively and significantly responded to both absolute and relative concepts of yield in the equations estimated with levels of variables as well as with their first-differences (Tables I and II). At sub-regional level, absolute yield is positively and significantly related with acreage under potato in all sub-regions except sub-region VI comprising Azamgarh, Ballia, Ghazipur and Varanasi districts. Among the sub-regions, the level of significance is higher in sub-regions III and V. The relative yield did not turn out significant in sub-regions I, II, IV, VI and VII. In the equations with first-differences, yield (absolute) variable is significant in only sub-regions I and III (Table II).

Potato acreage elasticity in the state as a whole with respect to four alternative concepts of yield varied from 0.20 to 0.63 and all of them are significant except that of relative yield. Over the sub-regions, the elasticity with respect to absolute yield varied between 0.15 and 0.62. The elasticity with respect to the relative yield is 0.37 and 0.70 in sub-regions III and V respectively. Among the sub-regions, the yield elasticities, in general, for all concepts are relatively higher in sub-regions III and V and lower in sub-regions IV and VII.

The above results reveal that the acreage under potato in the state as a whole is positively related with both price and yield variables, usually taken for profitability or gross returns.[12] At sub-regional level, sub-regions III, V and I have relatively higher elasticities with respect to both price and yield variables[13] and these are the regions which have recorded higher increase in their acreage under potato (Sangwan, 1987). On the other hand, sub-regions IV, VI and VII covering the districts in the eastern part of Uttar Pradesh have shown lower response to either or both of the price and yield variables and these regions have also recorded less increase in their potato acreage.

C. Risk Aversion

Both the risk variables, *i.e.*, variability of price and yield, measured in terms of their coefficient of variations of preceding three years' values have not turned out significant in the equations of levels (Table I) in any of the sub-regions as well as the state as a whole. However, these variables showed expected negative relation with potato acreage in the correlation matrix.[14] In equations with the first-differences (Table II), the variable of relative price risk has expected negative and significant regression coefficients in sub-regions I, III and V. These regions have also relatively higher price elasticity. The yield risk gives expected negative regression coefficients only in the equations of the state as a whole and sub-region I.

The above risk variables, firstly, point out that cultivators of potato are averse to changes in the level of relative variability especially due to price and not to the extent of variability alone. Secondly, the market oriented nature of production and consciousness about price risk are positively related as indicated in the case of potato. The yield risk not turning out significant may, *inter alia*, be due to the use of aggregated yield data, which is likely to iron out the extent of variations in yield over the years.

D. Adjustment Behaviour

Table I shows that out of the two lagged variables used as explanatory variables, only A_{t-1} entered significantly with positive sign in most of the equations. However, Table II depicts that the two years lagged changes in acreage, *i.e.*, (A_{t-2}-A_{t-3}) also significantly influenced the current changes in potato acreage of sub-regions I, II and IV. The values of price adaptation coefficients are unity when the values of area adjustment coefficient are positive between 0 and 1. This indicates inapplicability of adaptive expectational model simultaneously with area adjustment model or vice versa. Thus either a simple adaptive price expectational or partial area adjustment model seems to be a correct specification of farmers acreage supply behaviour.

The degree of adjustment to changes in terms of coefficients of adjustment computed from these regression coefficients of Tables I and II are presented in columns (3) and (6) of Table III. The adjustment coefficients are higher in the case of equations with absolute concepts than in those of relative concepts. All the values are within the expected range of 0 to 1. Sub-regions III and V show full adjustment to desired acreage in the equations of levels with absolute concepts of variables while the values of adjustment coefficient in the remaining sub-regions varied from 0.29 to 0.62. It implies that institutional and technological constraints affected the realisation of available incentives for potato cultivation in all the sub-regions except sub-regions III and V.[15] The values of these coefficients are much lower in the equations of levels using relative concepts of variables. It points that the long-run elasticity of acreage with respect to relative price and yield will be higher in magnitude vis-a-vis those obtained for absolute concepts. It substantiates our earlier argument that relative price or profitability is the concern of the farmers over the years while annual fluctuations in acreage may be largely explained by the reaction of the farmers to simpler concepts of absolute price or profitability.

IV

CONCLUSIONS AND POLICY SUGGESTIONS

The elasticities of potato acreage with respect to its price are not only positive for Uttar Pradesh and most of its seven sub-regions but also higher than those of important food crops like wheat, maize and rice. This lends support to the general view that supply of cash crops is more responsive to price changes than the crops largely cultivated for subsistence needs of the farmers. Even in the case of potato, price responsiveness varied over the sub-regions of the state. The yield elasticity of potato is also positive for the state as a whole and most of its sub-regions but their magnitudes are relatively higher in the regions falling in the western and central part of Uttar Pradesh. It is also revealed that only those regions have recorded higher increase in the potato acreage which felt the positive impact of both price and yield variables. It again supports the widely held view that the profitability is the main concern of farmers while allocating acreage under individual crops.

The coefficients of risk variables based on price and yield turned out significant only in the model with first-differences of supply variables. It implies that a change in the variability of price or yield is a better measure of risk than the levels of variability. The coefficient of price risk turned out significant in three sub-regions which have shown relatively higher response to price too, thus indicating a positive association between market orientation in production and risk consciousness of the producers. The coefficient of yield risk turned out significant only in one sub-region in spite of negative correlation between this variable and acreage of potato in most of the sub-regions.

The estimated equations also indicate that either a simple adaptive expectation or partial adjustment model may be a more correct specification of behavioural process of cultivators than considering both simultaneously in the estimating equation. Assuming the applicability of area adjustment postulate, it is revealed that the adjustment to desired change of potato acreage was higher in those sub-regions which had less acreage under the crop in the initial period of study and were also backed by the improving infrastructure over time. Hence, increasing the level of yield and strengthening of marketing facilities especially in the eastern part of the state emerge as policy suggestions for achieving higher growth rate of potato supply as well as more balanced dispersal of potato within the state.

S.S. Sangwan*

Received April 1990. Revision accepted July 1991.

NOTES

1. During the last decade (seventies) significant increases in output have been achieved through increase in yield in a few crops, which have a weight of 55 per cent in the index of agricultural production. These crops are wheat, paddy, sugarcane and potatoes (Government of India, 1982 *a*, p. 9).

2. A recent study relating to Orissa which accounted for only about 2.5 and 1.5 per cent of the all-India area under and production of potato respectively, has estimated the acreage elasticity with state-level data (Naik and Patnaik, 1984).

3. The only exception is the State of Kerala where tapioca (cassava) is the alternate root crop. The temperate climate of the Indo-Gangetic plains and hills of Eastern India and Himachal Pradesh are more suitable for potato cultivation. These areas account for nine-tenth of all-India potato area and production during the triennium 1980-83.

4. Potato is a hundred per cent irrigated crop in Uttar Pradesh. Other irrigated crops likely to compete with potato in this state are sugarcane, wheat and peas in the case of which the area irrigated accounted for 90, 83 and 78 per cent of the area under each crop respectively.

5. An important district here is one which cultivates potato in at least 1,000 hectares and this area is more than one per cent of its gross cropped area. The grouping of these districts into seven sub-regions corresponds with the crop complex regions delineated by Roy (1973).

6. A stationary process has a mean, variance and auto-correlation which do not change through time.

7. The regression coefficients of the equation with first-differences will always have lower significance than those of equations with levels because of the statistical properties of the two (Fisher, 1966). Hence, it is always better to estimate the regression equations simultaneously both with original data and the changes and to interpret the results together (Granger and Newbold, 1974).

8. The publications used for collecting the data are: Season and Crop Report, Department of Revenue, Directorate of Agricultural Statistics, Government of Uttar Pradesh (different annual issues); *Uttar Pradesh Ke Krishi Ankre* (Hindi), Government of Uttar Pradesh (various annual issues for recent data after 1978-79); Government of India (1969; 1975; 1978; 1982 *b*); and *Agricultural Situation in India* (various relevant issues).

9. The value of h-statistics is computed wherever possible and its value ($\leq \pm$ 1.645) does not indicate serial correlation except for sub-regions I and II (equations with relative and absolute concepts respectively). The equations of first-differences with absolute concepts have serial correlation in sub-regions III, V and VI. However, simultaneous estimation of equations with absolute and relative concepts enabled us to compare the effect of serial correlation, if any.

10. The short-run elasticity with respect to the independent variable, *i.e.*, $(dA/dX)(\bar{X}/\bar{A})$, where X is an independent variable, was calculated by multiplying the coefficient of each independent variable with the ratio of average of that variable and potato area over the period of the study.

11. To some extent it can be expected that relative price takes away the trend component of price increase. Moreover, farmers may be guided by simpler visible incentives in the short run but the relative price may be important in the long run as is evident from the values of adjustment coefficient of equations for the relative and absolute concepts.

12. Equations were also estimated with profitability (P x Y) variables using both the concepts, *i.e.*, absolute and relative and using both the models of levels and first-differences. Profitability elasticities for the state as a whole ranged from 0.21 to 0.45 at 1 per cent level of significance.

13. The absolute profitability elasticities of these regions were 0.36, 0.40 and 0.23 compared to 0.21 for the state as a whole. Almost similar results were obtained with other concepts of profitability.

14. In the equations estimated for Farrukhabad district alone (not included in Tables I and II), the risk variable due to relative yield gave negative regression coefficient even in the equations with levels.

---

*District Development Manager, National Bank for Agriculture and Rural Development, Dehra Dun (Uttar Pradesh).
The author is personally responsible for the views expressed and not the institution in which he serves.

Thanks are due to G.S. Bhalla and Kusum Chopra with whom the author had fruitful discussions at different stages of the work. The author is also thankful to the anonymous referee for useful suggestions and constructive comments.

15. The nearness of the districts covered under those regions to the agricultural universities of Pantnagar and Kanpur and potato seed farms, *inter alia*, may be an important factor in explaining the higher level of their realisation of available incentives.

REFERENCES

Askari, H. and J.T. Cummings (1977). "Estimating Agricultural Supply Response with Nerlove Model: A Survey", *International Economic Review*, Vol. 18, No. 2, June.

Durbin, J. (1970). "Testing for Serial Correlation in Least Squares Regression Where Some of the Regressors are Lagged Dependent Variables", *Econometrica*, 38, No. 3, May.

Fisher, F.M. (1966). A Priori Information and Time-Series, North-Holland Publishing Co., Amsterdam.

Government of India (1969). Farm (Harvest) Prices of Principal Crops in India, 1954-55 to 1965-66, Directorate of Economics and Statistics, Department of Agriculture and Co-operation, Ministry of Agriculture, New Delhi.

Government of India (1975). Farm (Harvest) Prices of Principal Crops in India, 1965-66 to 1970-71, Directorate of Economics and Statistics, Department of Agriculture and Co-operation, Ministry of Agriculture, New Delhi.

Government of India (1978). Farm (Harvest) Prices of Principal Crops in India, 1970-71 to 1974-75, Directorate of Economics and Statistics, Department of Agriculture and Co-operation, Ministry of Agriculture, New Delhi.

Government of India (1982 *a*). Economic Survey, 1981-82, Ministry of Finance, New Delhi.

Government of India (1982 *b*). Agricultural Prices in India, 1975-82, Directorate of Economics and Statistics, Department of Agriculture and Co-operation, Ministry of Agriculture, New Delhi.

Granger, C.W.J. and P. Newbold (1974). "Spurious Regression in Econometrics", *Journal of Econometrics*, Vol. 2, pp. 111-120.

Insergent, K. (1969). "Models to Explain Annual Changes of Potato Acreage in Great Britain Since 1955", *The Farm Economist*, Vol. 11, No. 10.

Jennings, A.N. and R.J. Young (1980). "Generalisation of the Nerlove Supply Model Using Time Series Methodology: An Application to Potato Plantings in Great Britain", *Journal of Agricultural Economics*, Vol. 31, No. 1, January.

Klein, L.R. (1976). A Text Book of Econometrics, Prentice-Hall of India Pvt. Ltd., New Delhi, pp. 188-194.

Naik, D. and S.C. Patnaik (1984). "Impact of Prices on Area, Production and Productivity of Potato in Orissa", *Agricultural Situation in India*, Vol. 39, No. 6, September.

Nelson, C.R. and H. Kangle (1981). "Spurious Periodicity in Inappropriately Deterended Data", *Econometrica*, Vol. 49, No. 3.

Nerlove, M. (1958). The Dynamics of Supply: Estimation of Farmers' Response to Prices, Johns Hopkins University Press, Baltimore.

Revell, B.J. (1974). "A Regional Approach to the Potato Acreage Planting Decision", *Journal of Agricultural Economics*, Vol. 25, No. 1, January.

Roy, B.K. (1973). "An Approach to Regionalisation of Types of Farming in India", quoted in P.S. Sharma (1973). Agricultural Regionalisation of India, New Heights Publishers and Distributors, Delhi.

Sangwan, S.S. (1985). "Dynamics of Cropping Pattern in Haryana: A Supply Response Analysis", *The Developing Economies*, Vol. 23, No. 2, June.

Sangwan, S.S. (1987). Dynamics of Potato Supply in India: A Case Study of Uttar Pradesh, Ph.D. Thesis, Jawaharlal Nehru University, New Delhi.