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Research Paper

Hectareage response study of wheat crop using nerlovian model for Gujarat state

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ABSTRACT : The present study on hectareage response of wheat has been carried out using Nerlov's model for Gujarat state. The state level data relating to area, production, productivity and farm harvest prices of wheat were obtained from the published and compiled information by Directorate of Agriculture, Gujarat State, Gandhinagar for the period starting from 1980-81 to 2007-08. On the basis of the correlation co-efficients of selected independent variables with current hectareage under wheat crop, single equation, linear as well as log-linear models were formed. The partial regression co-efficient of expected yield of wheat crop was significant at different levels in all the single equation models. Yield factors like lagged price and expected price played an important role in hectareage change for wheat crop, while, non-price factors like hectareage of competing crop and expected yield little influenced the hectareage of wheat crop.Risk factors like price risk, return risk and yield risk had not showed a significant role in hectareage change for wheat crop. According to R^2 and adjusted R^2, model HEWH = -13186.99 + 0.0108 HEWHL -5.1574 PWHL + 0.3095 EPWH+ 7.6970** EYWH +12046.26 REPWH + U_1 were found to be the best fitted model for prediction of hectareage of wheat crop in Gujarat state.

KEY WORDS : Hectareage, Nerlov's model, Risk factors, Correlation co-efficients, Wheat crop

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INTRODUCTION

Rabi crops occupies 551 lakh hectors of land in India and 36.27 lakh hectors of land in Gujarat state in which wheat, gram, rapseed-mustard, cumin and onion are dominant and important *Rabi* crops (Anonymous,2009). Wheat is widely cultivated food crop accounts an area of 26.06 m.ha with a production of 72.1 M.T. and productivity of 2710 kg/ha in India, while in Gujarat, it is grown in about 12.01 lakh ha with total production of 30.00 lakh tones and productivity of 2450 kg/ha (Anonymous, 2008).

For allocating their land to different crops, farmers do not consider the price alone, but they also consider many non-price factors like competing crops, cost and availability of inputs, whether fluctuation, disease pest infestation, consumption needs, risk and uncertainity, marketing facility and technological changes.

Many attempts were made to study the supply behaviour of different crop products, which is partly determined by acreage allocation, using various approaches like simple ratio of prices and area of the main and competing crops, link relative method (Kamala Devi, 1964). However, Walsh (1944) was the first, who has used regression analysis for studying acreage response to price variable. Such regression equation approach was replaced by a more realistic one suggested by Nerlove (1958) introducing the concept of expected price.

The present study on hectareage response of wheat has been carried out using Nerlov's model for Gujarat state with the following objectives :

- To identify the responsible price and non-price factors for hectareage change and the degree of their importance in hectareage response.
- To find out the best fitted model by comparing different single equation models for the predictability of crop hectareage of wheat crop of Gujarat state.

Review of literature :

Hectareage response of different crops to various price and non price factors has drawn the attention of many research workers, thus scanty of literature is available on comparison of different models for prediction of crop hectareage.

Nerlove (1958) brought about a basic change in the field of supply response study. In his study on dynamic supply response, he concluded that the expected price is important than the lagged year price in explaining supply response. Thus Nerlove hypothesized the relationship between the expected level of long run output and expected level of future price.

($X^e_t = a_0 + a_1 P_t + V_t$) which were explained through "Expectational Model" ($P_t - P_{t-1}$) = B ($P_{t-1} – P^e_{t-1}$) and "Partial Adjustment Model" ($X_t - X_{t-1}$) = r ($X_{dt} - X_{t-1}$).

For the study of fluctuation of area under wheat in Bihar, Bhagat (1985) used the linear form of model including variables like lagged acreage, lagged relative price, price risk, relative gross income, income risk, irrigation and rainfall. He indicated the significance of relative gross return as compared to that of relative price in explaining the variation in wheat acreage.

Khan and Iqbal (1991) studied the supply response of 10 major crops (wheat, rice, cotton, sugarcane, maize, pearl millet, sorghum, barley, chickpea and oilseeds) in Pakistan using time series data for the period 1956-57 to 1986-87. It is found that farmers in Pakistan do respond to changes in relative prices as well as yields in their crop allocation decisions.

Boyle and McQuinn (2001) studied the supply response models for Irish wheat and barley producers. The study incorporates risk aversion and uncertainty into the analysis. The presence of greater price volatility due to successive reform of EU agricultural policy exacerbates this point. This study follows on from previous work by applying a supply response model within a mean variance framework to a panel data set of Irish wheat and barley producers. Under this specification, Irish producers are actually found to be risk neutral in their production behaviour.

Alwan (2002) studied the supply response function based on the Nerlovian model was estimated for wheat produced in Irbid Governorate. Wheat area, in the model, was the dependent variable in the supply response function. The independent variables were, wheat planted area in the current and previous year, respectively, the weighted price of wheat in the previous year deflated by the consumer price index, the holding fragmentation co-efficient in the previous year, the yield risk, and the amount of rain in millimeters during the early months of the season. He concluded, fragmentation of holdings was the major factor that negatively affects wheat production.

Tingre *et al.* (2006) examined the acreage response to various factors determining the decisions regarding the allocation of land to wheat and *Rabi* jowar in Vidarbha. The study was based on secondary data collected from various Government Publications. Nerlovian lagged adjustment model was used for the acreage response analysis. The results of study showed that lagged area under wheat and *Rabi* jowar influenced positively the current acreage under these crops. Yield risk variable in production of wheat influenced positively the current acreage under this crop, whereas it was negatively influenced in casR of *Rabi* jowar. Lagged price of competing crop influenced negatively the current acreage under wheat and *Rabi* jowar. In wheat lagged yield of competing crop *i.e.* gram affected negatively the current acreage under wheat.

Shafiq *et al*. (2007) estimated the supply response of wheat in all the agro-ecological zones of Punjab using the modern technique of co-integration. The time series data used were collected for all the zones during 1970-2001. The study revealed that wheat acreage is significantly influenced by price of wheat and other competing crops such as cotton and sugarcane. Among the non-price factors, irrigation and rainfall have positive effect on wheat acreage in the short run. The wheat supply elasticities are found to be inelastic both in the short and long run. The long-run own price acreage elasticities were 0.53, 0.46 and 0.49 in cotton zone, rice zone and mixed zones, respectively.

MATERIALS AND METHODS

Source of data :

The state level data relating to area, production, productivity and farm harvest prices of wheat were obtained from the published and compiled information by Directorate of Agriculture, Gujarat state, Gandhinagar for the period starting from 1980-81 to 2007-08.

Selection of competing crop :

The competing crop was determined for the crop under study on the basis of time of sowing and/or magnitude and direction of the correlation between hectareage of these crops.

Selection of variables :

Correlation co-efficients of the tentative selected variables were worked out for the crop under study, and for its competing crops. Then, effective variables had been selected on the basis of correlation co-efficient for inclusion in different single equation models.

Specification of variables :

Let X : crop and WH : Wheat.

Hectareage variables :

HEX : Current hectareage under X crop in 00' ha.

HEXL : Lagged hectareage of X crop in 00' ha.

Price variables :

PXL : Lagged price of X crop in rupees per quintal.

RPXL : Lagged relative price of X crop calculated as,

RPXL = PXL / PCL

where, PCL: Lagged price of competing crop

EPX : Expected price of X crop calculated as the average of the last three year's price.

REPX : Relative expected price of X crop.

Calculated as,

REPX = EPX / EPC

where, EPC : Expected price of competing crop.

Yield variables :

EYX : Expected yield of X crop calculated as average of the last three year's yield in kg/ha.

Return variables :

GRXL : Lagged gross return of X crop in rupees.

RGRXL : Lagged relative gross return of X crop calculated as,

RGRXL = GRXL / GRC

where, GRC : Lagged gross return of the competing crop.

EGRX : Expected gross return of X crop as average of last three year's gross return.

REGRX : Relative expected gross return of X crop calculated as,

REGRX = EGRX / EGRC.

where, EGRC : Expected gross return of the competing crop.

Irrigation variables :

RIXL = Lagged relative irrigated area of X crop.

RIXL = IXL / ICH

Where, IXL : Lagged irrigated area of X crop.

ICH : Lagged irrigated area of competing crop.

Risk variables :

PRSK, YRSK, RRSK : Risk due to price, yield and return, respectively.

Calculated as, standard deviation of the last three year's price, yield and gross return, respectively.

Nerlovian adjustment lagged model :

The response to any change in an economic variable is not a uniform lag, but it is generally distributed lag (Nerlove, 1958).

The long run supply, A_t*, is assumed in Nerlovian frame work to be related to the price (Pt) in the simple linear manner:

$$A_t^* = a + bP_t + U_t \quad \text{(I)}$$

The variation in A_t* is connected by variations in observed supply with the assumption of the following relationship between actual and the long run desired levels of supply.

$$A_t - A_{t-1} = r(A_t^* - A_{t-1}),\ 0 = r = 1 \quad \text{(II)}$$

where, r is the co-efficient of adjustment, by substituting value of A_t* in equation II

$$A_t = A_{t-1} + r(a + b P_t + U_t - A_{t-1}), \quad \text{(III)}$$

$$= \acute{a} + B_1 A_{t-1} + B_2 P_t + V_t \quad \text{(IV)}$$

where, $a = ar$ $V_t = r U_t$

$B_1 = 1 - r$ $B_2 = b r$

This conceptual model IV will act as a basis for the single equation models for the crop under study, The parameters of the model had been estimated by the ordinary least square (OLS) method, The reduced form would remain basically the same, even if one include more independent variables.

Formation of different single equation models :

On the basis of the correlation co-efficients of selected independent variables with current hectareage under wheat crop, single equation, linear as well as log-linear models were formed (Aitken,1935). Care had been taken that the independent variables included in a model, form a logical set and also the absence of multicollinearity between the pairs of independent variables would be ascertained using the following criterion.

Multicollinearity is considered to be not serious when the condition that R = | r | is fulfilled (Klein, 1962).

where, r : Simple correlation co-efficient between the two independent variables included in the model.

R : Multiple correlation co-efficient corresponding to the model.

Specification of the single equation models

(I)	HEWH	=	$B_0 + B_1$ HEWHL + B_2 PWHL + B_3 EPWH + B_4 EYWH + B_5 REPWH + U_1
(II)	HEWH	=	$B_0 + B_1$ HEWHL + B_2 PWHL + B_3 EPWH + B_4 EYWH + B_5 GRWHL + U_2
(III)	HEWH	=	$B_0 + B_1$ HEWHL + B_2 PWHL + B_3 EPWH + B_4 EYWH + B_5 PRSK + U_3
(IV)	HEWH	=	$B_0 + B_1$ HEWHL + B_2 PWHL + B_3 EPWH + B_4 EYWH + B_5 RRSK + U_4
(V)	HEWH	=	$B_0 + B_1$ HEWHL + B_2 PWHL + B_3 EPWH + B_4 EYWH + B_5 HEC + U_5
(VI)	HEWH	=	$B_0 + B_1$ HEWHL + B_2 PWHL + B_3 EPWH + B_4 EYWH + B_5 HECL + U_6

RESULTS AND DATA ANALYSIS

The findings of the present study as well as relevant discussion have been presented under following heads :

Correlation :

In order to know the degree of association between the hectareage under the crop and the variables affecting the current hectareage, correlation co-efficients were worked out using 17 variables (Table 1). Funnel was observed as a

Table 1 : Correlations between variables of wheat in Gujarat state

	HEWH	HEWHL	PWHL	RPWHL	EPWH	REPWH	EYWH	GRWHL	RGRWHL	EGRWH	REGRWH	RIWHL	PRSK	YRSK	RRSK	HEC	HECL
HEWH	1.0000	0.5566**	0.4639**	0.1060	0.5439**	0.3791*	0.7724**	0.3258^^	0.0869	0.1648	-0.0735	0.2998^	0.4817**	-0.0361	0.3333^^	-0.7913**	0.2558^
HEWHL		1.0000	0.2916^	-0.1889	0.4191*	0.1422	0.5403**	0.3337^^	0.1296	0.2218	-0.2877^	-0.3288^^	0.4553*	-0.1043	0.4406*	0.3813*	0.7820**
PWHL			1.0000	0.5086**	0.6854**	0.8815**	0.7309**	0.7027**	0.4456*	0.9144**	0.6014**	0.2216	0.5097**	0.1908	0.6153**	-0.6050**	-0.4092*
RPWHL				1.0000	0.3959*	0.6316**	0.1409	0.1072	0.4230*	0.3171^^	0.3030^	0.4743**	0.1753	-0.0633	0.3977*	-0.0259	-0.4462*
EPWH					1.0000	0.8587**	0.7576**	0.7433**	0.5075**	0.9334**	0.6352**	0.1646	0.4753**	0.0778	0.6027**	-0.6203**	-0.3442^^
REPWH						1.0000	0.5518**	0.5057**	0.3650*	0.6236**	0.5481**	0.1470	0.1908	-0.0672	0.4810**	-0.6393**	-0.2134
EYWH							1.0000	0.7190**	0.4610*	0.7670**	0.4204*	0.1874	0.5957**	0.0755	0.5656**	0.7891**	0.3132^
GRWHL								1.0000	0.8413**	0.8591**	0.7550**	0.3435^^	0.3542^^	-0.0220	0.6638**	0.0749	-0.3015^
RGRWHL									1.0000	0.5286**	0.6964**	0.3719*	-0.0171	0.0569	0.4262*	0.2516^	-0.3050^
EGRWH										1.0000	0.8194**	0.3663*	0.3382^^	-0.0722	0.5034**	-0.3791*	-0.5579**
REGRWH											1.0000	0.6024**	-0.1866	-0.0179	0.1166	-0.3984*	-0.8082**
RIWHL												1.0000	0.4308*	0.2455	0.0186	0.1065	-0.7728**
PRSK													1.0000	-0.5400**	0.4007*	0.3356^^	0.0683
YRSK														1.0000	-0.0607	-0.5042**	-0.4262*
RRSK															1.0000	-0.6096**	-0.6273**
HEC																1.0000	0.2692^
HECL																	1.0000

*, **, ^ and ^^ indicate significance of values at P=0.05, 0.01, 0.1 and 0.2, respectively

Table 2 : Partial regression co-efficients for different single equation models for wheat crop in Gujarat state

Model → / Variable	I	II	III	IV	V	VI
Constant	-13186.59	-10260.36	-11552.97	-9750.44	-19373.80	-12533.39
HEWHL	0.0108	0.0062	0.0767	-0.0078	0.0285	0.091
PWHL	-5.1574	-3.7744	-2.3505	-4.1696	8.0786	0.7837
EPWH	0.3095	3.3632	-0.5154	1.3558	-8.8077	-8.8103
EYWH	7.6970**	6.9654**	7.51**	6.8451**	10.9808*	8.5036^^
REPWH	12046.26	–	–	–	–	–
GRWHL	–	-0.0649^	–	–	–	–
PRSK	–	–	-0.0248	–	–	–
RRSK	–	–	–	0.0038	–	–
HEC	–	–	–	–	-0.1197	–
HECL	–	–	–	–	–	0.0943
R^2	0.7714	0.5791	0.7247	0.6010	0.7582	0.6791
Adj R^2	0.6526	0.4380	0.6513	0.4686	0.4936	0.4082
Multiple R	0.8845	0.7665	0.8579	0.7883	0.8678	0.8245

*, **, ^ and ^^ indicate significance of values at P+0.05, 0.01, 0.1 and 0.2, respectively

competing crop of wheat in Gujarat state.

The positively significant influence on wheat hectareage was observed by lagged hectareage, lagged price, expected price, expected yield and price risk and the negative correlation was observed with current hectareage of competing crop in Gujarat state. Price risk was significant at different levels which influence the current hectareage, while no influence or little influence was observed for yield risk of wheat crop in the state.

Single equation models :

Single equation multiple regression models were fitted using the selected 17 variables. In the selection of the set of independent variables for each of the models the following two points were considered :

- The set of independent variables in the model are logical.
- Absence of multicollinearity between the explanatory variables included in the model.

Each of the linear as well as log linear equations were tried and the co-efficients of multiple determinations (R^2) were computed with a view to compares their predictability. On this basis, linear form was found to be better fitted as compared to the log linear form. Thus, the linear form of the equation was selected for the present study.

Composition of different models :

All the single equation models tried for wheat crop included, lagged hectareage of the corresponding crop. They also included the area under the competing crop. The single equation models were composed according to correlation co-efficient of the different variables with the crop hectareage.

The single equation models of wheat crop in Gujarat state :

The results presented in Table 2 indicate that the co-efficient of multiple determination (R^2) ranged from 0.5791 (Model II) to 0.7714 (Model I) and the adjusted co-efficient of multiple determination (Adj R^2) ranged from 0.4082 (Model VI) to 0.6526 (Model I). The model I had the highest predictability, while model II had the lowest predictability.

The partial regression co-efficient of expected yield of wheat crop was significant at different levels in all the single equation models. The co-efficient of lagged gross return was negative and significant at 20% level in model II. According to R^2 and adjusted R^2, model I was found to be the best fitted model for prediction of hectareage of wheat crop in Gujarat state.

Tingre *et al*. (2006) indicated that acreage of the competing crop affected negatively the current acreage under wheat. Shafiq and Javed (2007) pointed out in their study, that wheat acreage was significantly influenced by price of wheat. In their study of supply response models, Boyle and McQuinn (2001) reported that the Irish producers of wheat and barley were found to be risk neutral in their production behavior. Sanjeev Kumar (1985) also observed no impact of risk in his study of supply response of Haryana's farmers.

Summery and conclusion :

For the study, Nerlovian Adjustment Lag Model was adopted as a base. The linear form of the multiple regression equation was employed.

Major findings of the present study for wheat crop are as under :

- On the basis of Adj R^2, single equation model I (HEWH = $B_0 + B_1$HEWHL + B_2PWHL + B_3EPWH+ B_4EYWH +B_5REPWH + U_1) had been selected as a best fitted model for prediction of wheat hectareage for Gujarat state.
- Yield factors like lagged price and expected price played an important role in hectareage change for wheat crop, while, non-price factors like hectareage of competing crop and expected yield little influenced the hectareage of wheat crop.
- Risk factors like price risk, return risk and yield risk had not showed a significant role in hectareage change for wheat crop.

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