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Hectareage response of castor crop in the Rajkot District of Saurashtra region of Gujarat

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Abstract
The present study was conducted in order to identify the models for predicting crop hectareage of castor crop in the Rajkot district of Gujarat state. The investigation was carried out on the basis of secondary data covering the period of 21 years (2000-01 to 2020-21). The linear multiple regression technique adopting Nerlovian adjustment model was employed. Eight single equation and four simultaneous equation models were tried for the selected crop. The model selected on the basis of adjusted coefficient of multiple determination, RMSE, MAE and MAPE values is as $HECS= -112.0 + 0.340\ HECSL_1 + 0.009\ HECT + 0.022\ YCSL_1 + 153.50\ REPCS - 0.076^{**}\ RFT + 0.107^{*}\ PRSK + 0.016\ YRSK$.

Keywords: Hectareage, Castor, Nerlovian adjustment model, Single equation model, Simultaneous equation model, Adjusted coefficient of determination, RMSE, MAE, MAPE

Introduction

Gujarat is a significant state in India in terms of its contribution to agricultural growth. It covers 19.6 million hectares (19.6%) of the country's total land area. The state of Gujarat plays a prominent role in castor production in India.

Among the crops grown in the Rajkot district, castor is one of the most dominant oilseed crops. The total area and production of castor crop in the Rajkot district in the year 2020-21 were 55.19 "00" ha and 124.40"00" MT respectively (Directorate of Agriculture, Gujarat state, Gandhinagar).

Land is one of the most important and finite resource in agriculture. Thus, the optimum allocation of land to agricultural crops is of great importance. The allocation of land to different crops is affected by both price and non-price factors.

However, understanding how producers make decisions to allocate land among crops and how decisions about land use are affected by changes in prices and their instability is essential for predicting the supply of staple crops and, consequently, evaluating the global food supply situation (Haile *et al.*, 2013) [5].

Price relationships have a significant influence on decisions regarding the type and quantity of agricultural production activity. Farmers are generally believed to be responsive to producer prices (Ezekiel *et al*., 2007) [4]. According to Weersink *et al.* (2009) [9], own and competing crop prices are the essential variables in explaining acreage response. An increase in a crop's own price is expected to have positive impact on the crop's acreage (Tahir, 2014) [8]. It is expected that farmers would allocate their limited land resources to that crop enterprise which the price tends to be encouraging. This is quite rational as the allocation of land to a better-priced crop would bring more profits to farmers.

The non-price factors comprise of mainly competing crops, cost and availability of inputs, weather fluctuations, disease pest infestation, consumption needs, risk and uncertainity, marketing facilities, technological changes *etc*. Hence, crop hectareage is determined by several factors.

Nerlove's formulation of agricultural supply response is one of the most widely used econometric models in the empirical studies. The model developed incorporates one year as well as two year lagged dependent variable as an explanatory variable. The study of the factors considered by farmers in acreage allocation under castor crop, will help to understand the decision making of farmers about the acreage allocation at micro level.

Considering the significance of the castor crop in country's economy and lack of research work on comparison of different hectareage response models, particularly in Gujarat state, the present investigation on hectareage response of castor crop was carried out.

Keeping the above-mentioned facts, the following specific objectives have been framed for the study.

- To identify various price and non-price factors influencing the crop hectareage allocation under castor crop.
- To compare simultaneous equation models with the single equation models for the predictability of crop hectareage of castor crop.
- To suggest the models for prediction of hectareage for the selected crop.

Methodology

Source of data

The study was based on secondary data collected for the period of 21 years from 2000-01 to 2020-21. Theannual data for related to hectareage and yield was collected from Directorate of Agriculture, Gujarat state, Gandhinagar (DAG). The data pertaining to farm harvest prices was collected from Directorate of Economics and Statistics, DAC & FW, Ministry of Agriculture and Farmers Welfare, GoI, New Delhi.The data related to rainfall was collected for the month of sowing and total annual rainfall.

Nerlovian adjustment lagged model

According to, Nerlove (1958) [7], the long run supply, A_t^*, is assumed in Nerlovian framework to be related to the price (P_{t-1}) in the simple linear manner:

$$A_t^* = a + bP_{t-1} + U_t \qquad (1)$$

The relationship between actual and the long run desired levels of acreage:

$$A_t - A_{t-1} = \delta(A_t^* - A_{t-1}), 0 \le \delta \le 1 \qquad (2)$$

Where, δ is known as the Nerlovian coefficient of adjustment and $(A_t - A_{t-1})$= actual change and $(A_t^* - A_{t-1})$= desired change.

Now, by substituting value of A_t^* in equation (2) from equation (1)

$$A_t = A_{t-1} + \delta(a + bP_{t-1} + U_t - A_{t-1}) \qquad (3)$$

$$A_t = \alpha + \beta_1 A_{t-1} + \beta_2 P_{t-1} + V_t \qquad (4)$$

Where,

$\alpha = a\delta, V_t = \delta U_t,$
$\beta_1 = 1 - \delta, \beta_2 = b\delta$

This equation-4 acted as a basis for the eight single equation and for simultaneous equation model (SE model) for the crop under study. The parameters of single equation models and simultaneous equation models were estimated by the ordinary least square (OLS) method and two stage least square (2SLS) method, respectively.

Selection of competing crop

Selection of competing crops was done on the basis of its total area, sowing seasonand/or the magnitude as well as direction of correlation between the area of these crops. In Rajkot district cotton was selected as competing crop.

Selection of independent variables

Out of all the variables effective explanatory variables for inclusion in different single equation models and simultaneous equation models were selected on the basis of magnitude of correlation coefficient and their interrelationships.

Specification of the variables

Specification of the variables included in the present investigation is as below:

Let X: Crop selected for the study
CS: Castor
CT: Cotton
C: Competing crop

Area variables

HEX: Current hectareage under 'X' crop in 00'ha.
$HEXL_1$: One year lagged hectareage of 'X' crop in 00'ha.
$HEXL_2$: Two year lagged hectareage of 'X' crop in 00'ha

Yield variables

YXL_1: One year lagged yield of 'X' crop in kg/ha
EYX: Expected yield of 'X' crop.

Price variables

PXL_1: One year lagged price of 'X' crop in rupees per quintal
PXL_2: Two year lagged price of 'X' crop in rupees per quintal
RPXL: Lagged relative price of 'X' crop calculated as:

$$\mathrm{RPXL} = \frac{\mathrm{PXL}}{\mathrm{PCL}}$$

Where, PCL_1: One year lagged price of competing crop.
EPX: Expected price of 'X' crop.
REPX: Relative expected price of 'X' crop calculated as:

$$\mathrm{REPX} = \frac{\mathrm{EPX}}{\mathrm{EPC}}$$

Where, EPC: Expected price of competing crop

Return variable

$GRXL_1$: One year lagged gross return of 'X' crop in rupees
RGRXL: Lagged relative gross return of 'X' crop calculated as:

$$\mathrm{RGRXL} = \frac{\mathrm{GRXL}}{\mathrm{GRCL}}$$

EGRX: Expected gross return of 'X' crop
REGRX: Relative expected gross return of 'X' crop calculated as:

$$\mathrm{REGRX} = \frac{\mathrm{EGRX}}{\mathrm{EGRC}}$$

Where, EGRC: Expected gross return of the competing crop

Rainfall variable

RFA: Total rainfall in the month of August in mm
RFT: Total annual rainfall in mm

Risk variable

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

Formation of different single equation models

While formation of single equation models, care was taken that the independent variables in a model form a logical set and also multicollinearity is absent between the pairs of independent variables. The multicollinearity was verified with the use of criteria known as Variance Inflation Factor (VIF) defined as:

The variance inflation factor for the j^{th} predictor is:

$$VIF_j = \frac{1}{1 - R_j^2}$$

Where, R_j^2: R^2-value (coefficient of determination) obtained by regressing the j^{th} predictor on the remaining predictors.

If, 1 < VIF < 5, no multi-collinearity,

5 < VIF <10, predictors are moderately correlated,

VIF >10, serious multi-collinearity requiring correction.

In time series data auto correlation is found more frequently. It was tested as (H_0) the absence of auto correlation ($\rho = 0$), against (H_1) the presence of auto correlation ($\rho \neq 0$) by using Durbin-Watson's (1970) 'd' statistic, which is given by

$$d = \frac{\sum_{t=2}^{n}(e_t - e_{t-1})^2}{\sum_{1}^{n} e_t^2}$$

Where, e_t = Error term of current year.

e_{t-1}= Error term of lagged year.

n = No. of observations.

Formation of simultaneous equation models

Four simultaneous equation models were formed for the selected crop. In order to solve the simultaneous equation model, identification of the model is a mandatory condition. Therefore, to identify the equations of model order as well as rank conditions were applied. The rank condition tells us whether the equation under consideration is identified or not, whereas the order condition tells us if it is exactly identified or overidentified.

All the equations included in the simultaneous equation models fulfilled both the conditions and hence, were exactly identified.

Result and Discussion

Correlation: In order to find out the degree of association between the hectareage under the crop and the variables affecting the current hectareage, correlation coefficients were worked out. The results revealed that lagged hectareage had a positive and highly significant correlation with current hectreage of castor crop. The association of yield factors is non-significant. The return variables and price risk showed a non- significant correlation with castor hectareage. The effect of rainfall variable is negative and non- significant.

Single equation models

The results provided in Table 1 suggested that the highest values of coefficient of determination (R^2) and adjusted coefficient of determination ($\bar{R}^2$) as well as minimum values of residual mean sum of square (RMSE), mean absolute error (MAE) and mean absolute percentage error (MAPE) corresponded to model-II (R^2=0.645, $\bar{R}^2$=0.454, RMSE=30.96, MAE=25.28, MAPE=32.19). Hence, model II was found to be the best fitted for prediction of area under castor hectareage in the Rajkot district.

The partial regression coefficient of lagged hectareage was positive and non- significant in all the models. Coefficient of current hectareage and lagged hectareage of competing crop (cotton) was positive and non-significant except for model I in which coefficient was negative. The partial regression coefficients of all the yield as well as price variables were positive and non-significant. The coefficients of gross return variables were positive and non-significant. The partial regression coefficients of rainfall in month of August were negative and non-significant, whereas, for total annual rainfall coefficients were negative and significant. Price risk had positive and significant coefficients in models I, II, VI and VII while yield risk had positive and non-significant coefficients in all the models.

Comparison of R^2,$\bar{R}^2$, RMSE, MAE and MAPE indicated that model II was the best suited for prediction of castor hectareage among the single equation models tried in the Rajkot district.

Simultaneous equation models

The result corresponding to four different SE models are presented in Table 2. All the SE models incorporated current hectareage of competing crop (cotton), lagged area of the crop under study and price risk variables. SE model I and II incorporated expected yield variable. Model I included lagged price, whereas model II included relative expected price variables. Model III and IV incorporated lagged gross return and expected return variables, respectively.

The study of results further indicated that the partial regression coefficients of lagged hectareage of castor and current hectareage of competing crop (cotton) were positive and non-significant for all the SE models.

The coefficient of expected yield of castor was positive and non-significant in model I while, positive and significant in model II. The coefficient of expected yield of cotton was negative and non-significant in model I while, negative and significant in model II.

Coefficients of lagged price and relative expected price of castor were positive and non-significant. The partial regression coefficients of lagged gross return and expected gross return of castor were positive and non-significant whereas, the partial regression coefficients of lagged gross return and expected gross return of cotton were negative and non-significant. The coefficients of price risk were positive and non-significant in all of the SE models.

Perusal of the results reflected that the coefficients of determination (R^2) range from 0.312 (SE model III) to 0.514 (SE model II). SE model II ranked first, both in case of $\bar{R}^2$ (0.306) and minimum error (RMSE= 36.45, MAE=28.46, MAPE = 36.78). It could be inferred therefore that among the SE models tried, SE model II had the best fit for predicting the castor hectareage in Rajkot district.

Table 1: Partial regression coefficients for different single equation models for castor in Rajkot district

Variable	Model							
	I	II	III	IV	V	VI	VII	VIII
Intercept	-2.933	-112.0	-34.813	-15.080	-36.496	15.540	-24.380	9.563
$HECSL_1$	0.259	0.340	0.160	0.197	0.235	0.198	0.046	0.125
HECT	-0.0002	0.009	0.026	-	-	0.006	0.027	0.028
$HECTL_1$	-	-	-	0.012	0.023	-	-	-
$YCSL_1$	0.016	0.022	-	0.014	-	-	-	-
$YCTL_1$	-	-	-	-	0.019	-	-	-
EYCS	-	-	0.013	-	-	-	-	-
$PCSL_1$	0.004	-	-	0.002	-	-	-	-
RPCSL	-	-	35.322	-	-	-	-	-
REPCS	-	153.50	-	-	82.026	-	-	-
$GRCSL_1$	-	-	-	-	-	0.000004	-	-
RGRCSL	-	-	-	-	-	-	2.759	-
EGRCS	-	-	-	-	-	-	-	0.00001
RFA	-0.134	-	-	-0.142	-	-0.141	-0.136	-
RFT	-	-0.076**	-0.063*	-	-0.072*	-	-	-0.071*
PRSK	0.114*	0.107*	0.075	0.099	0.072	0.097*	0.109*	0.075
YRSK	0.025	0.016	0.028	0.030	0.018	0.023	0.038	0.027
R^2	0.506	0.645	0.552	0.510	0.541	0.517	0.496	0.556
$\overline{R}^2$	0.241	0.454	0.312	0.246	0.294	0.309	0.279	0.365
RMSE	36.52	30.96	34.76	36.38	35.20	36.14	36.92	34.65
MAE	28.17	25.28	27.09	28.79	27.99	29.64	29.56	28.11
MAPE	34.60	32.19	32.79	35.14	33.67	33.66	35.14	33.28

Table 2: Partial regression coefficients for main equations corresponding to different simultaneous equation models for castor crop in Rajkot district

Variables	Model			
	I	II	III	IV
Intercept	-21.529	-261.147	6.195	0.506
$HECSL_1$	0.247	0.103	0.344	0.266
HECT	0.003	0.016	0.005	0.011
EYCS	0.053	0.068*	-	-
EYCT	-0.135	-0.191*	-	-
$PCSL_1$	0.010	-	-	-
$PCTL_1$	-0.007	-	-	-
REPCS	-	271.575	-	-
$GRCSL_1$	-	-	0.00001	-
$GRCTL_1$	-	-	-0.00001	-
EGRCS	-	-	-	0.00001
EGRCT	-	-	-	-0.00004
PRSK	0.141	0.140	0.037	0.111
R^2	0.431	0.514	0.312	0.313
$\overline{R}^2$	0.124	0.306	0.082	0.084
RMSE	40.30	36.45	41.43	40.81
MAE	30.95	28.46	32.98	31.37
MAPE	39.90	36.78	37.86	37.55

*, **Significant at 5% and 1% levels, respectively

Table 3: Recommended model for castor crop in Rajkot district

Model No.	Recommended Model	R^2	$\overline{R}^2$	MAPE
Model II	$HECS = -112.0+0.340HECSL_1+0.009HECT+0.022YCSL_1+153.50REPCS-0.076^{**}RFT+0.107^{*}PRSK+0.016YRSK$	0.645	0.454	32.19

Risk pertaining to price and yield were having positive impact in Rajkot Hence, in general, castor growing farmers are price risk as well as yield risk takers in Rajkot.

These findings are akin with Madhavan (1972) who reported the positive impact of lagged price and lagged acreage of competing crop on acreage of commercial crops, Cummings (1975) who studied the response of acreage for major cereals and cash crops, and reported positive price relation with acreage in most of the states in India and a study by Kaul and Sidhu (1971) on the acreage response for major crops in Punjab. They pointed out that lagged acreage had a positive sign for all the crops.

Conclusion

Among the single equation models tried for castor in Rajkot, the adjusted coefficient of determination ($\overline{R}^2$) was the highest (0.454) for model-II, while the highest value of $\overline{R}^2$ in case of SE models, was 0.306 (SE model II) with least error. Thus, the single equation model II, the form of which is given as under, and which explained around 65 per cent variation in the castor hectareage.

$$HECS = f(HECSL_1, HECT, YCSL_1, REPCS, RFT, PRSK, YRSK).$$

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