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Profit to Rice Growers at National Level and Jammu Region of J&K UT: Implication to Doubling the Farmers Income

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Abstract

Quantile regression (QR) has more scope in economic analysis. Economics data are usually contaminated, and the error assumptions are generally violated. QR can characterize the entire conditional distribution of the outcome variable, may be more robust to outliers and misspecification of error distribution, and provides robust and complete estimates compared to the mean regression. These advantages make QR attractive and are extended to apply for different types of data sets like agricultural, economic, and financial. The QR method has been applied to study the production and profit of rice as endogenous variable(s) and observed that by focusing on the variables fertilizer consumption(FC), quality seed rate (QSR), electricity consumption (EC), sale of power tillers (SPT), cost of seed (CS), cost of fertilizer and manure (CFAM), cost of insecticide (COI) and irrigation charges (IC), the production and profit of rice may be maximized at national level as well as in Jammu region. Further, the time series model has been applied on the data and observed that the best fitted model for production and profit were ARIMA (0 2 2) and ARIMA (0 1 1) based on AIC and SBIC criterion. The gain in profit percentage w.r.t cost has also been calculated for the year 2025 and shall be 136.62 percent. It is observed that the government is taking initiative by implementing the policies to enhance the income of the famers. From the study, it has been observed that, the variables cost of seed (CS), cost of fertilizer and manure (CFAM), cost of insecticide (COI) and irrigation charges (IC) may help the government to enhance the income two - three times in the coming years.

Key words: ARIMA; Box-Jenkins; Quantile regression model; Profit function; Fixed cost; Forecast.

1. Introduction

Agriculture plays a key role in the overall economic and social well-being in India. Economic growth in India has been broadly on an accelerating path. In 1951, the total National income coming from agriculture sector was 55 percent but now-a-times, it is stuck to mere 24 percent. The value addition per worker in agriculture grew slowly and income per farmer never crossed one-third of the income of a non-agriculture worker since 1980s. More than 65 percent population of India depends on rice (staple food), contributing 40 percent of the total food grain and plays a major role in diet, economy, employment, culture, and history. Total production of Rice during 2020-21 is estimated at record 121.46 million tonnes. It is higher by 9.01 million tonnes than the last five years' average production of 112.44 million tonnes.

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As far as Jammu is concerned, Jammu and Kashmir is basically an agrarian UT with 80 percent of the people engaged in agriculture for their livelihood. The current situation is not satisfactory in terms of food grains as the area under these crops have shown the disturbing trends and around 3.5 hectares area has been converted for commercial and other purposes which is being revealed by the Department of Agriculture, despite the fact that there is a sealing act on paddy land by the government for its conversion to some other activities which has caused the food deficiency in J&K and has already touched to 40 percent. Further, the increase in the area under these crops is less as they are seeming to be profitable (Present Status and Future Prospectus of Agriculture in Jammu and Kashmir, January 2021 DOI:10.9790/0837-201136267). As a matter of fact, J&K is not sufficient to feed its own people as a result a large quantity of rice (on an average 4.97 lakh tones) in a year are drawn from central pool to meet the deficient requirement of the UT. Above data reveals the clear deficiency of food grains in Jammu region of J&K (UT) as compared to National Level.

So far considering the above points, to overcome the deficiency of rice and to identify the parameters which will double the farmers' income at National as well as Jammu region. One must evaluate and study the regressor variables to maximize the production and profit of rice at National level and in Jammu region through robust models. Further, the constraints have been identified which the farmers' faced during the production and profit maximization of rice in Jammu region and to forecast the value(s) of production and profit of rice crop at National level.

2. Materials and Methods

In the present study, the data have been collected into two ways *i.e.*, Primary for Jammu region and Secondary at National level. The time series data over decades have been collected with respect to rice from various published sources/portals such as: Ministry of Agriculture, Government of India; Directorate of Economics and Statistics, Government of India; Reserve Bank of India; IASRI (Data Book) and Indiastat. For Primary data, from the Jammu region, two districts (Jammu and Kathua) selected purposively due to maximum rice growers; from each district 6 villages have been selected randomly and then from each village 10 farmers have been selected randomly. So, there were 120 farmers who have been surveyed through multistage sampling procedure for Jammu region of J&K UT. Ordinary least square (OLS), Quantile Regression (QR) and ARIMA technique(s) have been applied on the annual decadal data of production and profit of rice crop. QR presents a complete understanding of the effects of exogenous variables when a set of percentiles are modeled. QR is particularly useful when the rate of change in the conditional quantile, revealed by the coefficients of the regression, and extreme values are very important (Benhin 2008, Cameron and Trivedi 2009). QR model have been used to identify variables which may maximize the profit for rice growers. Just as the sample mean that minimizes the sum of squared residuals: $\hat{\varepsilon} = arg\ \min_{\varepsilon \epsilon \mathrm{R}} \sum_{i=1}^{n}(y_i - \varepsilon)^2$, *is* extended to the linear mean function $\mathrm{E}(Y|X = x) = x'/\beta$ by the solution of $\hat{\beta} = arg\min_{\beta \epsilon \mathbb{R}^p} \sum_{i=1}^{n}(y_i - x_i'\beta)^2$. The linear conditional quantile function, $(\tau|X = x) = x'\beta(\tau)$ can be estimated by the solution of $\hat{\beta}(\tau) = arg\ \min_{\beta \epsilon \mathbb{R}^p} \sum_{i=1}^{n} \rho_\tau(y_i - x_i'\beta)$, for any quantile $\tau \epsilon (0,1)$.

Moreover, Information regarding the problems faced by the farmers in rice production, and profit have been surveyed. Farmers were being asked to choose one of the five choices *i.e.*, strongly disagree, disagree, neutral, agree, strongly agree, then rank the problems which were proposed to them in a schedule and were identified by giving them ranks using Garrett's Ranking Technique (GRT). Garrett's formula for converting ranks into percent is

Percent position $= 100 * \frac{R_{ij}-0.5}{N_j}$ where, R_{ij} = rank given for i^{th} constraint by j^{th} individual, N_j = number of constraints ranked by j^{th} individual. The percent position of each rank be converted into scores by using table of Garrett and Woodworth (1969). For each factors, the scores of individual respondents be added together and divided by the total number of the respondents for whom scores be added. These mean scores for all the constraints be arranged in descending order; the constraints were accordingly ranked. After this, the main issue(s) of our concern is that how to select an appropriate model that can produce accurate forecast based on a description of historical pattern in the data and how to determine the optimal model orders. Box and Jenkins (1976) developed a practical approach to build ARIMA model, which is helpful in best fitting the given time series and satisfy the parsimony principle. In ARIMA models, a non-stationary time series is made stationary by applying finite differencing of the data points. The mathematical formulation of the ARIMA (p d q) model using lag polynomials is

$$\varphi(L)(1-L)^d y_t = \theta(L)\varepsilon_t \; i.e;\; 1-\sum_{i=1}^{p}\varphi_i L^i \;(1-L)^d y_t = 1+\sum_{j=1}^{q}\theta_j L^j \;\varepsilon_t$$

where

$$AR(p)model\colon \varepsilon_t = \varphi(L)y_t;$$
$$MA(q)model\colon y_t = \theta(L)\varepsilon_t$$
$$ARMA(p\;q)\;model\colon \varphi(L)y_t = \theta(L)\varepsilon_t.$$

Here, $\varphi(L) = 1-\sum_{i=1}^{p}\varphi_i L^i$ *and* $\theta(L) = 1+\sum_{j=1}^{q}\theta_j L^j$. The Box-Jenkins methodology does not assume any pattern in the historical data of the series to be forecasted. Rather, it uses a three-step iterative approach of model identification, parameter estimation and diagnostic checking to determine the best parsimonious model from a general class of ARIMA models. These three-step processes were repeated several times until a satisfactory model finally selected. A crucial step in an appropriate model selection is the determination of optimal model parameters. One criterion is that the sample ACF and PACF, other widely used measures for model identification are Akaike Information Criterion (AIC) and Schwartz Bayesian Information Criterion (SBIC) which are defined as AIC(p) = $n\ln(\hat{\sigma}_e^2/n)+2p$ and SBIC(p) = $n\ln(\hat{\sigma}_e^2/n)+p+p\ln(n)$. Here, n is the number of effective observations, used to fit the model, p is the number of parameters in the model and $\hat{\sigma}_e^2$ is the sum of sample squared residuals. The optimal model order is chosen by the number of model parameters, which minimizes AIC and BIC. The final selected model is used for forecasting future values of the time series.

3. Results and Discussion

The summary statistics for exogenous variables area under rice (AUR), fertilizer consumption (FC), quality seed of rice (QSR), electricity consumption (EC), annual rainfall (AR), pesticide consumption (PC), sale of tractors (ST) and sale of power tillers (SPT) in case of production of rice (POR) whereas in case of profit of rice (PrOR), the exogenous variables were cost of machine labour (CML), cost of seed (CS), cost of fertilizer and manure (CFAM), cost of insecticides (COI), irrigation charges (IC) and fixed cost (FC) with the values of mean, standard error as well as coefficient of variation as shown by table 1.

Table 1: Summary statistics of exogenous variables for the production and profit of rice in India

Production(Million ton)				Profit (Rs/hectare)			
Variable (Unit)	**Mean**	**±SE ($\bar{X}$)**	**CV (in %)**	**Variable (Rs/hectare)**	**Mean**	**±SE ($\bar{X}$)**	**CV (in %)**
AUR (Million hectare)	43.40	0.23	2.64	**CML**	19721.81	2387.11	40.14
FC (Thousand ton)	19870.53	1072.45	26.44	**CS**	3039.09	380.25	41.49
QSR (Lakh quintal per hectare)	38.73	4.97	62.89	**CFAM**	1548.38	169.27	36.25
EC (Giga-watt)	102008.80	5546.62	26.63	**COI**	3135.96	325.94	34.47
AR (Millimeter)	1154.82	17.51	7.42	**IC**	633.54	84.49	44.23
PC (Million ton)	50335.91	1716.31	16.70	**FC**	1009.57	97.86	32.14
ST (Number)	331702.80	33383.87	49.30				
SPT (Number)	26197.08	3526.91	65.95				

Here, variable sale of power tillers (SPT) has maximum CV (65.95 percent) followed by quality seed of rice (QSR) whereas the variable area under rice (AUR) has minimum CV (2.64 percent) followed by the variable annual rainfall (AR) which clearly indicates lot of variation among the independent variables may be due to the presence of influential observations. In case of profit, the variable IC has maximum value of CV (44.23 percent) followed by CML and the variable FC has minimum CV (32.14 percent) followed by COI.

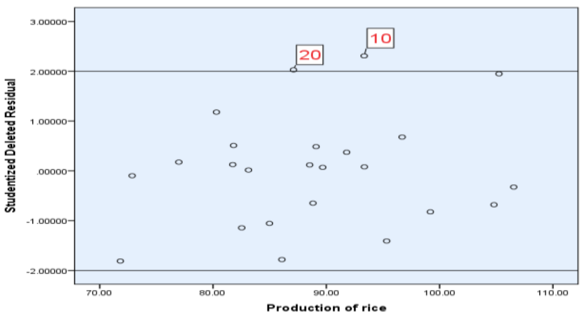

Figure 1: Graph of studentized deleted residual against endogenous variable

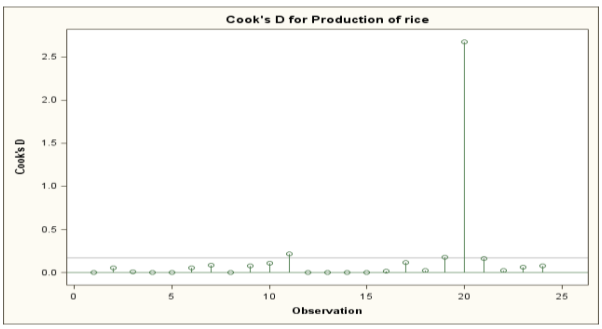

Figure 2: Graph of cook's distance for the production of rice in India

The behaviour of the data has been evaluated through studentized deleted residual, Cook's Distance, Breusch-Pagan test and Durbin Watson test. It was concluded from figure 1 that, the observations which were coming out of the range -2 to +2 were the outliers by studentized deleted residual and from figure 4, the observations which showed sudden jumps in the graph were influential observations by Cook's Distance. Moreover, Breusch-Pagan test and Durbin Watson test showed that there is no heteroscedasticity and no autocorrelation present in the data as their Lagrange multiplier (LM) value is 0.96 (p-value = 0.99) which was non-significant and the value of D = 2.36, respectively. Moreover, the values of R^2 and adj. R^2 be 0.93 and 0.89, which depicts the model is going to be good fitted and the F-value (26.60**) which means the model is adequate.

Table 2: Estimation of regression coefficients through OLS and quantile regression at different quantiles using Cobb-Douglas production function for India

Variable	Regression coefficients				Gain in Percentage
	OLS (SE)	Quantile regression			
		τ = 0.50 (SE)	τ = 0.75 (SE)	τ = 0.90 (SE {E-08})	τ = 0.90 w.r.t OLS
Constant	−0.9372 (1.9536)	−1.1684 (0.6752)	1.8827 (0.0892)	−2.8305 (0.0186)	
AUR	1.2634** (0.3146)	1.3178** (0.1087)	0.9218** (0.0144)	1.8009** (0.2990)	42.5439
FC	−0.1799 (0.1698)	−0.2175** (0.0587)	−0.2697** (0.0078)	−0.2296** (0.1610)	27.6264
QSR	0.2246** (0.0390)	0.2115** (0.0135)	0.2093** (0.0019)	0.3486** (3.7100)	55.2092
EC	−0.1050 (0.0885)	−0.0776* (0.0306)	−0.0673** (0.0040)	−0.1510** (8.4200)	43.8095
AR	0.3936** (0.1145)	0.4216** (0.0396)	0.2753** (0.0052)	0.3853** (0.1090)	-2.1087
PC	−0.0424 (0.0703)	−0.0681* (0.0243)	−0.0688** (0.0032)	0.0976** (6.6800)	-130.1886
ST	0.0333 (0.0664)	0.0502* (0.0229)	0.0312** (0.0030)	−0.0520** (6.3100)	-256.1561
SPT	0.0121 (0.0756)	0.0114 (0.0261)	0.0257** (0.0035)	0.0230** (7.1900)	90.9090
Returns to scale	1.9270	2.0125	1.4633	2.6555	

***= significant at 5% and **= significant at 1%**

The regression coefficient by OLS indicates that the variables *i.e.*; AUR, QSR and AR were statistically significant. A detailed representation of the parameter coefficients at quantiles 0.50, 0.75 and 0.90 have been revealed by Table 2. The variables AUR, FC, QSR, EC and SPT were significant and maximum at $\tau = 0.90^{th}$ as compared to OLS. The gain in magnitude for the variables AUR, FC, QSR, EC and SPT were as 42.54 percent, 27.62 percent, 55.21 percent, 43.80 per cent and 90.91 percent which can maximize the production of rice in India. Moreover, after the 0.90^{th} quantile, the estimate of the parameter remains constant indicated that there is no more effect of multicollinearity, outliers and influential observations on the data. The value of returns to scale at $\tau = 0.90^{th}$ was 2.65 which means production increases with the increase in all inputs at $\tau = 0.90^{th}$.

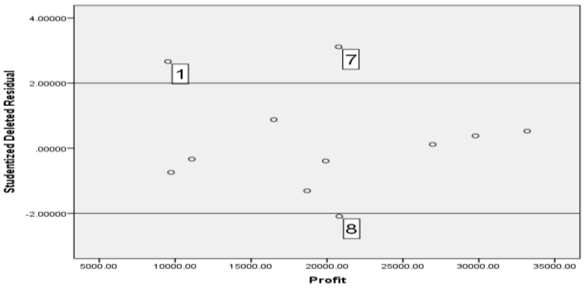

Figure 3: Graph of studentized deleted residual against endogenous variable

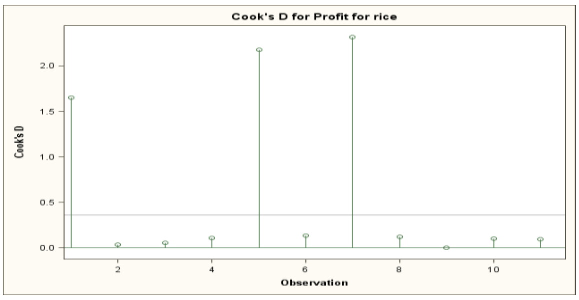

Figure 4: Graph of cook's distance for profit of rice crop in India

It has been observed from the figures 3 and figure 4 that, the observations which were coming out of the range -2 to +2 were the outliers by studentized deleted residual and the observations which showed the sudden jumps in the graph were influential observations by Cook's distance. Breusch-Pagan test and Durbin Watson test showed that there was no heteroscedasticity present in the data as its LM value is 3.98 with p value = 0.67 but the autocorrelation was present in the data as the value of D = 2.72 respectively. Moreover, the values of R^2, adj. R^2 and F-value were 0.99, 0.98 and 83.73**, which is significant, and the model is adequate for study.

Table 3: Estimation of regression coefficients through quantile regression at different quantile using Cobb-Douglas profit function for India

Variable	**Regression coefficients**			**Gain in Percentage**
	OLS (SE)	**Quantile regression**		
		τ = 0.5 (SE)	**τ = 0.75 (SE)**	**τ = 0.75 w.r.t OLS**
Constant	−3.9688 (1.7781)	−6.2959** (0.3313)	−2.4551* (0.6842)	
CML	−1.2604 (0.4818)	−1.9825** (0.0898)	−1.2361** (0.1854)	-1.9280
CS	0.7717 (0.3917)	0.8347** (0.0730)	0.9626** (0.1507)	24.7376
CFAM	0.4402 (0.2208)	0.6098** (0.0411)	0.5750** (0.0850)	30.6224
COI	0.1002 (0.1519)	0.1278* (0.0283)	0.1866* (0.0584)	86.2275
IC	−0.7957** (0.1577)	−0.8360** (0.0294)	−0.8987** (0.0606)	12.9446
FC	2.0879* (0.4923)	2.7670** (0.0917)	1.6602** (0.1894)	-20.485
Returns to scale	3.4000	4.3393	3.3844	

***= significant at 5% and **= significant at 1%**

After the model coming out to be significant, the regression coefficient has been evaluated by OLS and at different quantiles. The variables IC and FC were statistically significant by OLS with the value of 0.79 and 2.08. The result in Table 3 showed that the cost of variables CS, CFAM, COI and IC was significant and the increase in magnitude of these variables at $\tau = 0.75^{th}$ as compared to OLS were 24.73, 30.62, 86.22 and 12.94 percent may maximize the profit of rice in India. Moreover, after the 0.75^{th} quantile, the estimates of the parameter remain constant. The value of returns to scale at $\tau = 0.75^{th}$ was 3.38 indicating that the profit increases with the increase in all inputs at 0.75^{th} quantile.

After the identification of production and profit of rice variables at National level, the survey has been conducted in the two districts (Jammu and Kathua) of Jammu region of J&K UT. From these two districts, 120 farmers have been surveyed and their socio-economic status is as:

Table 4: Socio-economic status of the farmers of rice crop in Jammu and Kathua districts of Jammu region

Variable	**Category**	**District**		**χ^2-test (*p*-value)**
		Jammu (%)	**Kathua (%)**	
Age (in years)	<30	2 (1.70)	1 (0.80)	6.86 (0.03)
	30-50	17 (14.20)	31 (25.80)	
	>50	41 (34.20)	28 (23.30)	
Schooling (Classes passed)	0-8	18 (15.00)	9 (7.50)	5.02 (0.17)
	Below matric	13 (10.80)	13 (10.80)	
	Matric	17 (14.20)	18 (15.00)	
	Above matric	12 (10.00)	20 (16.70)	
Occupation (Agricultural Farming)	Primary	38 (31.70)	39 (32.50)	0.04 (0.84)
	Secondary	22 (18.30)	21 (17.50)	

The socio-economic status of farmers of Jammu and Kathua districts of Jammu region of Jammu and Kashmir UT has been presented in Table 4. The result showed that the variable age was significant as their χ^2 value was 6.86. The farmer with age more than 50 were more indulged in farming *i.e.*, 34.20 percent followed by age group 30-50 in Jammu district, the reason behind this may be that the youth is moving towards private sector rather than agriculture sector whereas in Kathua district, the farmers with age group 30-50 were more indulged in farming *i.e.*, 25.8 percent followed by age group more than 50. The farmers with age less than 30 were less indulged in farming in both the districts.

Further, the variable schooling was non-significant with χ^2 value as 5.02 but associated with the districts. Also, the variable occupation was divided into two categories as primary farming and secondary farming which was again not significant with χ^2 value as 0.04 and is associated with districts. The production and profit of rice in Jammu division have been studied and the variables have been identified for knowing the status in case of rice in J&K UT.

The exogenous variables in case of production were area under rice (AUR), seed rate (SR), fertilizer consumption (FC), labour for rice (LFR) and herbicide consumption (HC) whereas in case of profit, the variables were cost of harvesting, threshing & winnowing (CHTW), cost of seed (CS), cost of fertilizer (COF), cost of labour (COL), cost of herbicide (COH), cost of irrigation (COI) and cost of transplanting (COT). The graph of studentized deleted residuals plotted against endogenous variable as shown in figure 5, it was concluded that the observations which were coming out of range -2 to +2 were outliers.

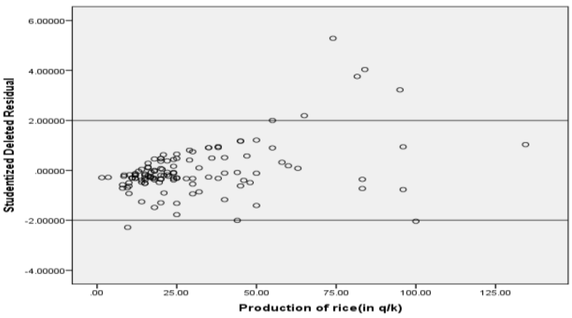

Figure 5: Graph of studentized deleted residual against endogenous variable

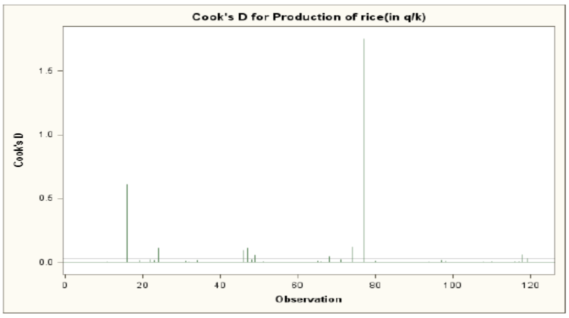

Figure 6: Graph of cook's distance for the production of rice in Jammu region

Also, from the graph of Cook's distance as shown in figure 6, it can be observed that some of the observations have the large value of cook's distance and also showed sudden jumps, so were influential observations. The observations (16, 47 and 74) which were both outliers and influential observations affect both the slope and intercept. Breusch-Pagan test indicated that the heteroscedasticity was present in the data as their LM value was 23.47 (*p*-value=0.0001) which was statistically significant and Durbin Watson test showed that the autocorrelation was not present in the data as the D value = 1.56. The values of R^2 and adj R^2 be 0.81, 0.80 and the F-value was 96.47** which showed that the model was significant. Thus, the exogenous variables considered for the study were adequate.

The behaviour of the data disobey the assumptions of error term and the regression coefficient by OLS indicated that the variable SR was statistically significant with the value 0.14 as shown in Table 5 whereas; quantile regression illustrated a positive and statistically significant effect of AUR on the production at quantiles 0.5^{th} and 0.95^{th}. Moreover, after the 0.95^{th} quantile, the estimates of the parameter remain constant indicated that there was no more effect of multicollinearity, outliers and influential observations on the data. The variables AUR was significant based on sign, size and significance and maximum at $\tau = 0.95^{th}$ with the increase in magnitude as 74.73 percent as compared to OLS which can maximize the production of rice in Jammu division. The value of returns to scale at $\tau = 0.95^{th}$ was 2.45 which increases the production of rice with the increase in all inputs at 0.95^{th}quantile. The behaviour of profit of rice growers in Jammu region have also been studied with the following graphs and tests.

Table 5: Estimation of regression coefficients through OLS and quantile regression at different quantiles using Cobb-Douglas production function for Jammu region of J&K UT

Variable (per kanal)	Regression coefficients				Gain in Percentage
	OLS	Quantile regression			
		τ = 0.50	τ = 0.75	τ = 0.95	τ = 0.95 w.r.t. OLS
Constant	1.1800	0.6600	1.4902	3.4188*	
AUR (Quintal)	1.1860	0.9469*	1.4138	2.0724**	74.7386
SR (Kilogram)	0.1496*	0.1682**	0.0841	0.1466	-2.0053
FC (Kilogram)	0.0797	0.1599	0.2378	0.2397	200.7528
LFR (Number)	−0.5645	−0.3960	−0.9095	−1.4711	160.6023
HC (Milliliter)	0.0395	0.0380	0.0485	−0.1086	-374.937
Returns to scale	1.4548	1.3130	1.7842	2.4587	

***= significant at 5% and **= significant at 1%**

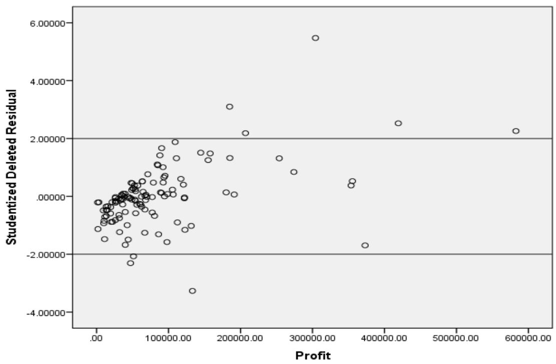

Figure 7: Graph of studentized deleted residual against endogenous variable

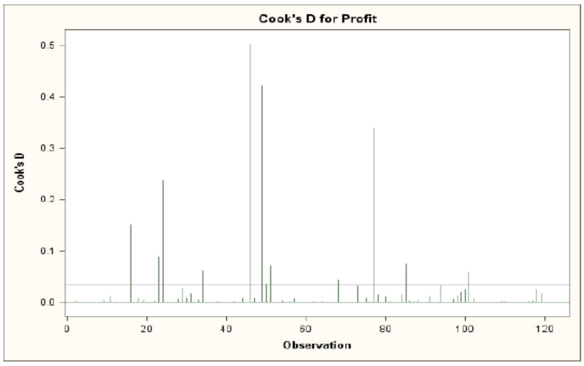

Figure 8: Graph of cook's distance for profit of rice crop in Jammu region

The values of studentized deleted residual were used to construct the plot against endogenous variable and resulted that the some of the observations were the outliers as shown in Figure 7 whereas, from the Figure 8, it can be observed that the observations were coming out of cut off line were influential observations as these observations showed sudden jumps in the graph. The some observations (24, 46, 49 and 77) were both outliers and influential observations which affect both the slope and intercept. Breusch-Pagan test and Durbin Watson test showed that both heteroscedasticity and autocorrelation were present in the data with LM value as 102.96 (p-value = 0.0001) and D = 1.22 respectively. Moreover, the values of R^2 and adj R^2 are 0.61 and 0.63, depicting that the model was going to be good fit and the F-value was (27.03), which was found to be significant.

Table 6: Estimation of regression coefficients through OLS and quantile regression at different quantiles using Cobb-Douglas profit function for Jammu region of J&K UT

Variable (per kanal)	Regression coefficients				Gain in Percentage
	OLS	Quantile regression			
		τ = 0.50	τ = 0.75	τ = 0.95	τ = 0.95 w.r.t. OLS
Constant	4.4279**	4.6597**	3.5393**	5.1133**	
CHTW	0.0708	0.0557	0.1709	0.1115**	-88.85
COS	−0.0396	−0.1201*	−0.0668	−0.1530**	286.36
COT	0.9707**	1.3896**	0.7104**	0.3975**	-60.25
COF	0.3543	−0.0016	0.0835	0.3520**	-64.80
COI	0.1445	0.0737	0.2619**	0.1668**	-83.32
COL	−0.5076**	−0.6375**	−0.1540	0.0323	-106.36
COH	−0.1210	0.0144	−0.0798	−0.0946**	-21.81
Returns to scale	0.8721	0.7742	0.9261	0.8125	

***= significant at 5% and **= significant at 1%**

The behaviour of the data showed that there is a violation of the error assumptions and the regression coefficients by OLS method mislead the results as shown in Table 6. So, to overcome from such situation, quantile regression has been applied and illustrated a positive, negative and statistically significant effect of the variables at 0.95 quantile. The overall result reveals that the variable COS was significant at $\tau = 0.95^{th}$ and the gain in magnitude was286.36 as compared to OLS which can maximize the profit to rice growers in Jammu region of J&K UT. Moreover, after the 0.95^{th} quantile, the estimates of the parameter remain constant. The value of returns to scale at $\tau = 0.95^{th}$ was 0.81 which means there is slight increase in profit with the increase in all inputs at 0.95^{th} quantile.

The constraints have also been studied which the farmers' faced during the time of production and profit of the rice crop in Jammu and Kathua districts as shown in table 7. The foremost constraint faced by farmer were scarcity of labour during peak season in both the districts with Garrett values as 67.60 and 67.00 followed by non-availability of power machines at appropriate time and lack of electricity whereas; in case of profit, the major constraint faced by the farmer was rate fluctuation with Garrett values as 70.40 followed by lack of storage facility and high rate of interest in both the districts.

Table 7: Garrett ranking of the constraints for production and profit of rice in Jammu region

Production			Profit		
Factors	**Constraints**	**Rank (Garrett value)**	**Factors**	**Constraints**	**Rank (Garrett value)**
F1	Shortage of quality seed	4 (53.70)	F1	Crop failure	9 (44.00)
F2	Non availability of suitable HYV	5 (51.65)	F2	Lack of market facility	8 (55.15)
F3	Non availability of fertilizer in adequate quantity	7 (47.05)	F3	Intervention of middle man	4 (63.90)
F4	Shortage of herbicide	8 (42.65)	F4	Lack of storage facility	2 (67.90)
F5	Scarcity of labour during peak season	1 (67.60)	F5	Lack of transport facility	7 (57.10)
F6	Lack of irrigation facility	6 (49.65)	F6	Village far from market	6 (59.35)
F7	Lack of electricity	3 (56.05)	F7	High rate of interest	3 (66.30)
F8	Non availability of power machines at appropriate time	2 (59.35)	F8	Lack of delivery system at village level	5 (61.15)
			F9	Rate fluctuation in crops	1 (70.40)

After this, the main concern is to select an appropriate model for production and profit forecast. The behaviour, correlogram and the best model for forecasting of production and profit have been studied through ARIMA modeling

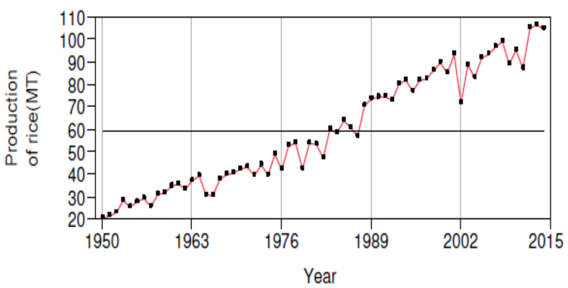

Figure 9: Behaviour of the annual production of rice in India

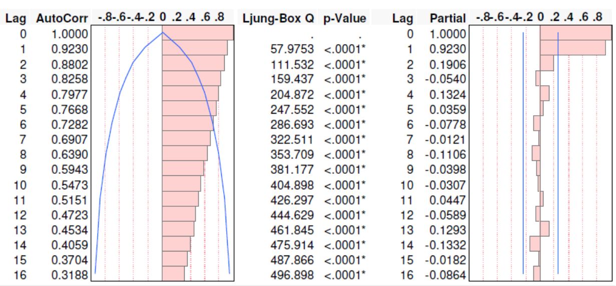

Figure 10: Correlogram of annual production of rice in India

The line chart of rice production for India showed that the time is on x-axis and rice production on y axis as shown in Figure 9. Long-term increasing pattern of data indicates that it is non-stationary with mean (59.36), standard deviation (25.46) and trend augmented Dickey-Fuller (–6.05). Further, the augmented Dickey-Fuller showed the non-significant results *i.e.*, accept the null hypotheses of non-stationarity. The correlogram for yearly rice production data through ACF and PACF plots in which spikes are coming outside from the insignificant zone and fails to follow the assumption of randomness of the data as shown in Figure 10. So, forecasting rice production through ARIMA model has been estimated after transforming the variable. The logarithmic and differenced technique is utilized to make variable stationary. Firstly, the 1st order difference of the variable has been utilized which depicts that the data was still non-stationary. Thereafter, to achieve the stationarity, differencing of order 2 has been taken. After differencing, the mean and standard deviation were constant whereas, the trend ADF (–17.41).

Table 8: Different models for annual production of rice in India

Model	**Intercept**	**Significance of parameters/model**	**AIC**	**SBC**	**R^2**
ARIMA(0 2 2)	Yes	Significant	–216.40	–209.97	0.95
ARIMA(1 2 2)	Yes	Non-significant	–214.44	–205.87	0.95
ARIMA(2 2 2)	Yes	Non-significant	–212.45	–201.73	0.95
ARIMA(2 2 1)	No	Significant	–210.82	–204.39	0.94
ARIMA(2 0 0)	Yes	Significant	–205.21	–198.69	0.89

Several ARIMA models were developed based on Box-Jenkins methodology. Among them the best five models have been proposed based on minimum AIC (Akaike Information Criterion), SBIC (Schwartz Bayesian Information Criterion) and the value of R^2 as shown in Table 8. The model ARIMA (0 2 2) had lowest AIC (–216.40) and SBIC (–209.97) values with the value of R^2 (0.95).

Table 9: Parameter estimates of ARIMA (0 2 2) for annual production of rice in India

Term	**Lag**	**Estimate**	**Std error**	***t* ratio**	***p*-value**	**MAPE**	**–2logliklehood**	**Constant estimate**
MA1	1	1.7833	0.1112	16.04	<.0001	1.8514	–222.3997	–0.0002
MA2	2	–0.7834	0.1053	–7.44	<.0001			
Intercept	0	–0.0002	0.0001	–2.27	0.0268			

The estimates of the parameter are shown in table 9 having MA (1) as 1.78, MA (2) as –0.78 and intercept as –0.0002 which were positively and negatively significant respectively. Further, ARIMA (0 2 2) model has also been selected because of minimum values of MAPE (1.85) and – 2 log likelihood (–222.39) which usually indicate a best fitted model according to the above three stages. The model verification is concerned with checking the residual of the model to see if they contain any systematic pattern which still can be removed to improve on the chosen ARIMA model.

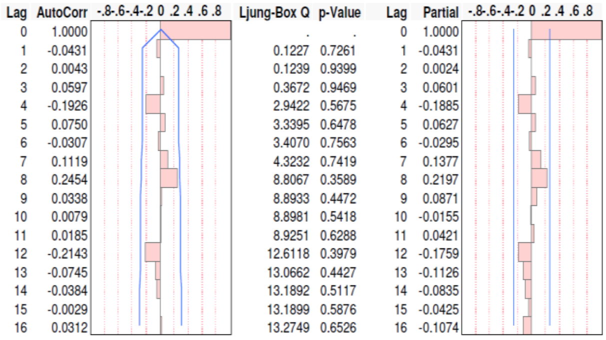

Figure 11: ACF and PACF plots of ARIMA (0 2 2) for annual production of rice in India

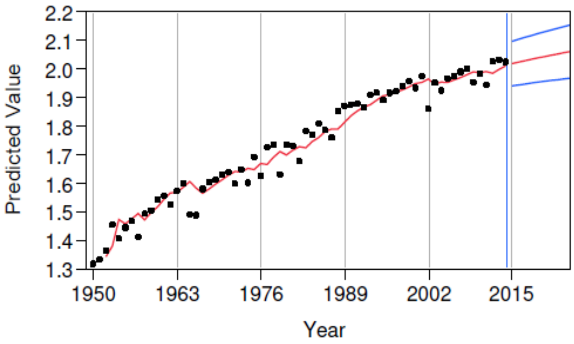

Figure 12: Forecasting graph of ARIMA (0 2 2) for annual production of rice in India

The ACF and PACF plots of the residual indicate 'good fit' of the model as shown in Figure 11. Moreover, *p*-values of Ljung-Box Q test are greater than the significance level (0.05), so we can conclude that the residuals are independent, and the model meets the assumption of randomness. ARIMA models are developed basically to forecast the corresponding variable. Figure 12 presents the graphical representation for forecasting of ARIMA (0 2 2) model which depicts that the trend is upward.

The line chart for profit of rice crop in India has been represented by Figure 13 and indicates that it is non-stationary with mean (19721.81), standard deviation (7548.71) and trend augmented Dickey-Fuller (-2.78).

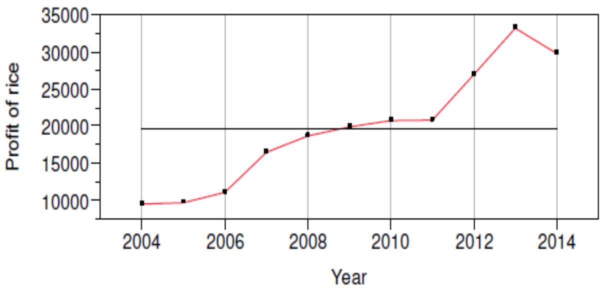

Figure 13: Behaviour of the annual profit of rice crop in India

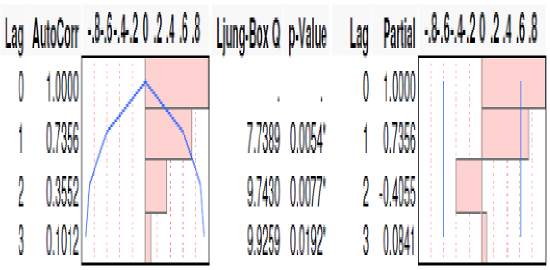

Figure 14: Correlogram of annual profit of rice crop in India

The ADF showed the non-significant results *i.e.*, accept the null hypotheses of non-stationarity. The ACF and PACF plots depicts that the spikes are coming outside from the insignificant zone as shown in Figure 14 and fails to follow the assumption of randomness of the data. After differencing of order 1, stationarity has been achieved with mean (0.04), standard deviation (0.05) and trend ADF (-2.34). We may say that series is stationary at 1st order difference.

Table 10: Different models for annual profit of rice crop in India

Model	Intercept	Significance of parameters/model	AIC	SBIC	R^2
ARIMA (0 1 1)	Yes	Significant	–25.6164	–25.0112	0.886
ARIMA (1 1 1)	Yes	Non-significant	–24.495	–23.5873	0.895
ARIMA(1 1 0)	Yes	Non-significant	–24.0353	–23.4301	0.866
ARIMA(1 0 1)	Yes	Non-significant	–21.1082	–19.9145	0.732
ARIMA(1 0 0)	Yes	Significant	–19.137	–18.3412	0.652
ARIMA(0 0 1)	Yes	Significant	–12.7685	–11.9727	0.532

Among the several models, the best five models have been proposed based on minimum AIC, SBIC and the value of R^2 as shown in Table10. The model ARIMA (0 1 1) had lowest AIC (–25.61) and SBIC (–25.01) values with the value of R^2 (0.88).

Table 11: Parameter estimates of ARIMA (0 1 1) for annual profit of rice crop in India

Term	Lag	Estimate	Std-error	*t* - ratio	*p*-value	MAPE	– 2loglikelihood	Constant estimate
MA (1)	1	0.9999	0.3700	2.70	0.027	0.0460	–29.6163	0.0546
Intercept	0	0.0546	0.0046	11.74	<0.0001			

The estimates of the parameter MA (1) as 0.97 and intercept as 0.05 which were positively significant as shown in Table 11 and the ARIMA (0 1 1) model has also been selected because of minimum values of MAPE (0.04) and – 2 log likelihood (–29.61) which usually indicate a best fitted model.

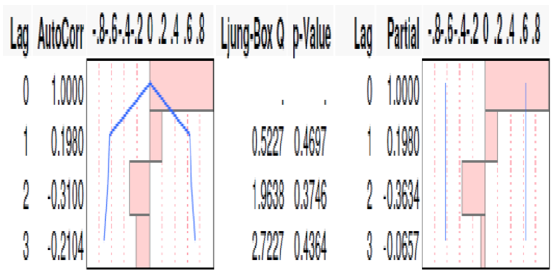

Figure 15: ACF and PACF plots of ARIMA (0 1 1) for the profit of rice crop in

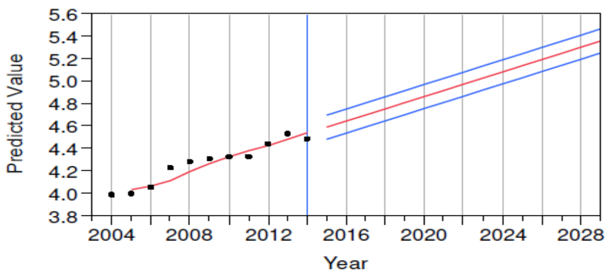

Figure 16: Forecasting graph of ARIMA (0 1 1) for the profit of rice crop in India

The ACF and PACF plots of the residual and p-values of Ljung-Box Q test indicated that the residuals are independent, and the model meets the assumption of randomness (see Figure 15) whereas Figure 16 showed the graphical representation for forecasting of ARIMA (0 1 1) model.

Table 12: Prediction table of ARIMA (0 1 1) for the cost of cultivation and Profit of rice crop in India

Year	(Cost) Forecasted (Actual value) (Rs/hectare) [L-95, U-95]	(Profit) Forecasted (Actual) (Rs/hectare) [L-95, U-95]	Gain in %age (profit w.r.t cost)
2017-18	44814.14 (44810.32) [39799.24, 50460.94]	49805.55 (49800.26) [38931.56, 63716.74]	111.13
2018-19	49528.14 [43985.72, 55768.93]	56483.78 [44151.75, 72260.28]	114.04
2020-21	60495.90 [53726.14, 68118.68]	72646.71 [56785.85, 92937.67]	120.08
2022-23	73892.42 [65623.53, 83203.23]	93434.68 [73035.21, 119531.90]	126.45
2025-26	99749.51 [88587.09, 112318.40]	136284.5 [106529.70, 174350.10]	136.62

The gain in percentage for the profit of rice crop has been evaluated with respect to cost of cultivation as shown in Table 12. The gain in percentage for rice crop for the forecasted year 2025-26 will be 136.62 percent which represents that if farmer will spend Rs 100 for rice crop, then he will get a profit of 136.62 percent more than the actual investment.

4. Conclusions

1. In case of production, the variables area under rice (AUR), fertilizer consumption (FC), quality seed rate (QSR), electricity consumption (EC) and sale of power tillers (SPT) whereas in case of profit the variables cost of seed (CS), cost of fertilizer and manure (CFAM), cost of insecticide (COI) and irrigation charges (IC) will maximize the production and profit of rice at National level.
2. In case of production, the variable area under rice (AUR) whereas in case of profit the variable cost of seed (COS) will maximize the production and profit of rice for Jammu region.
3. The problem(s) faced by the farmers' during production of rice in the Jammu region was scarcity of labour during peak season followed by non-availability of power machines at appropriate time whereas in case of profit, the maximum problem faced by farmer was rate fluctuation followed by lack of storage facility.
4. The forecasted value of the production of rice based on estimated model for the year 2022 shall be 116.13 MT same as per the projection in annual report 2020-21(www.agricoop.nic.in). The forecasted value of the profit of rice on the basis of estimated model ARIMA (0 1 1) for the year 2025 shall be Rs. 136284.5 per hectare.

The gain in profit percentage with respect to cost has also been calculated for the year 2025 and shall be 136.62 percent which means government is still making the policies and taking initiatives to achieve the goal of doubling the farmers' income at National level but the situation is different and poor in case of Jammu division of J&K UT. So, in order to enhance the farmers' income in Jammu division as well, the studied variables FC, QSR, EC, SPT, CS, CFAM, COI and IC apart from the problems faced by farmers in case of production and profit may help the government to take appropriate initiatives and policies.

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