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Modeling the Province Wise Yield of Rice Crop in Pakistan Using GARCH Model

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ABSTRACT

In our present study, GARCH family models are used for modeling and forecasting the rice yield of four provinces of Pakistan during the period of 1947-48 to 2008-09. Also Auto regressive, moving average and Autoregressive moving average models are described. Thus, the selected GARCH models for all provinces are also presented for forecasting purpose on the basis of two criteria AIC (Akaike information criteria) and SIC (Schwarz information criteria). This assessment recommended that the province of Punjab in Pakistan better forecast as compared to other three provinces.

Keywords: *Rice Yield, ARMA, GARCH and Pakistan.*

1. INTRODUCTION

Agriculture plays a constructive role in the development of both developed and especially in developing countries like Pakistan, India, Sri Lanka and Bangladesh. In addition to meeting nutritional food rice is also important from the economical point of view. Rice is an alternative source of wheat in all over the world particularly in Pakistan. Pakistani fine rice is famous in both the national and international market for their fine quality and softness. Pakistan is the third biggest rice exporting country of the world after meeting its national requirements. Different varieties of rice are grown in Pakistan for example Super Basmati, Basmati PK-385, Irri-6 and KS-282 etc. Pakistan is primarily known for its fragrant rice (Super Basmati/ Basmati PK-385). The average yield of rice is 23.74/ forty kg per acre in 2008-09.

Several studies have been carried out to model and forecast the production of major crops in Pakistan such as wheat (Hamid et al. [1]; Iqbal et al. [2], rice (khan and khan [3], cotton (Anwar and Javed [4] and sugarcane Rizvi [5] in Pakistan. Khan and khan [3] & Muhammad et al. [6] performed a practical study of modeling and forecasting of rice production in Pakistan. Ali et al. [7] worked on the several varieties of rice in Punjab in Pakistan to see who the best among others is. The authors concluded that KS-282, NIAB-IR9, IR9, IR-6, Basmati-2000, Super basmati, 99512 and PK-5261-1-2-1 are produced higher yield of rice rather than the other varieties of rice under study.

2. METHODOLOGY

The main objective of this research work is to develop a suitable model and then forecast the yield rice in the four provinces of Pakistan using ARCH family models because in the previous literature all the authors discussed the only ARMA methodology rather than the ARCH family models. For that purpose, we employed annually data of rice yield of four provinces of Pakistan during the period of 1947-48 to 2008-09 (62 yearly observations) which have been taken from Agriculture Statistics of Pakistan. All rice yield observations are calculated by taking the logarithm transformation (e.g. Saleem [8] and Irfan et al., [9] rather than the differences approach which was famous in time series analysis but we used a new approach of logarithm transformation. We estimated and forecast the models using both EViews 5.1 and Minitab 15 programs. In this section, four various time series models: AR, MA, ARMA and GARCH will be described briefly.

Autoregressive (AR) Process

Autoregressive model of order "p" depend upon the current values of the variable under study and its lagged values plus a random disturbance term and written its equation as:

$$Y_t = \delta + \sum_{j=1}^{p} \theta_j Y_{t-j} + \varepsilon_t \qquad (1)$$

Where δ is the intercept term, θ_j's are the unknown parameters of the autoregressive process and ε_t is an uncorrelated random error term.

Moving average (MA) process: Moving average model of order "q" consists on the current values of the variable under study and the lagged values of the error term plus a random disturbance term and written its equation as:

$$Y_t = \delta + \sum_{l=1}^{q} \theta_l e_{t-l} + \varepsilon_t \qquad (2)$$

Where δ is the intercept term, θ_l's are the unknown parameters of the moving average process and ε_t is an uncorrelated random error term.

Autoregressive moving average (ARMA) process

If the autocorrelation function towards zero is very slowly and the partial autocorrelation function have no cut off point then ARMA model is favored in which just we combine the AR and MA process and written its equation as:

$$Y_t = \delta + \sum_{j=1}^{p} \theta_j Y_{t-j} + \sum_{l=1}^{q} \theta_l e_{t-l} + \varepsilon_t \qquad \textbf{(3)}$$

Where δ is the intercept term, θ_j's are the unknown parameters of the autoregressive process, θ_l's are the unknown parameters of the moving average process and ε_t is an uncorrelated random error term.

Generalized Autoregressive Conditional Heteroscedasticity (GARCH) Process

Bollerslev [10] developed a GARCH (p, q) model which takes both the components of autoregressive and moving average in the form of the heteroscedasticity variance, GARCH model was the extension of the ARCH model which was proposed by Engle [11]. A simple GARCH (1, 1) model is given as:

$$h_t = \alpha_o + \alpha_1 \varepsilon_{t-i}^2 + \beta_1 h_{t-1} \qquad \textbf{(4)}$$

The GARCH (1, 1) must be stationary if $\alpha_1 + \beta_1 < 1$ where α_1 *and* β_1 must satisfy the non negativity condition.

3. RESULTS AND DISCUSSION

Table1. Shows the statistical features of the rice yield of all the provinces in Pakistan. It can be seen that yield data of rice of all the provinces is not normal because of its kurtosis values. **Figure 1 & 2** illustrate firstly the time series plot of the yield rice in Pakistan which indicates that all four provinces don't follow the assumption of stationary Gujrati, [12] and secondly after taking the logarithm transformation, all the four variables becomes stationary Irfan et al. [9]. **Table 2.** Also confirms the stationary through ADF unit root test means reject the hypothesis of our study which is as under:

H_o : data under study is not stationary

H_1 : data under study is stationary

After checking the assumption of stationary which is essential in time series analysis, we choose tentative models for all variables under consideration through AIC (Akaike information criteria) and SIC (Schwarz information criteria) which are most powerful to diagnosis the best models but in the end we select the most appropriate models for all four provinces in Pakistan which are: ARMA (2, 1), ARMA (1, 1), ARMA (2, 1) and ARMA (2, 1) for Punjab, Sindh, Khyber P.K and Balochistan respectively. **Table 3** shows the results of parameter estimation of all four variables under consideration, the correlogram of all selected models clearly tell us that the residuals are purely random which means there is no need to look out for another ARMA model for all four variables. The results also indicates that MA terms of all the four provinces are highly significant and the correlogram of squared residuals (not reported) show high quantity of autocorrelation in residuals which allow us to carry on further applying the ARCH family models which will be helpful to remove autocorrelation in residuals.

The results in **Table 4.** Indicate the parameters of all the four provinces in Pakistan by the help of ARCH family models. If the sum of the ARCH and GARCH coefficients exceed to one then we must conclude that volatility is very high and the variances are not stationary, in our study volatility is present in the provinces of Punjab and Khyber P.K. However, in Sindh and Balochistan the sum of ARCH and GARCH coefficients is close to one, indicating that volatility is moderately present. Lastly, after the selection of the models and its estimation of its parameters, the last step of our study is to forecast by the help of both AIC (Akaike information criteria) and SIC (Schwarz information criteria). In **Table 5**, the results of forecast for all provinces using the selected GARCH model rather than ARMA methodology because ARMA approach control the mean term of the data only when variance fluctuates than GARCH model is favorable to capture the problem of variance which is also an important assumption of stationary. This comparison suggested that Punjab better forecast as compared to the other three provinces of Pakistan as it has minimum errors.

4. CONCLUSIONS

In this paper, we applied ARMA methodology and GARCH family models for modeling and forecasting the rice yield of four provinces of Pakistan for the period of 1947-48 to 2008-09. First of all we used ARMA methodology to search out the best models for all provinces on the basis of AIC (Akaike information criteria) and SIC (Schwarz information criteria) after this, we used GARCH models to cope the problem of variance which is essential assumption of stationary in time series analysis. This comparison suggested that the province of Punjab better forecast as compared to other three provinces as it has minimum forecast errors. For the increase of yield of rice in all provinces, Government of Pakistan should be take initiative steps like: Government should be provided the loans to the formers, the price of seeds should be reasonable, solve the problem of lack of water especially in the three provinces except of Punjab & import the high quality yielding verities of rice from other countries.

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APPENDIX

Table1: Descriptive statistics of rice yield data

Variable	Mean	StDev	Skewness	Kurtosis
Punjab	-0.26	10.76	-0.15	2.97*
Sindh	0.31	14.65	0.03	3.20*
Khyber P.K	-0.53	14.55	-0.35	4.67*
Balochistan	0.65	38.23	0.91	5.40*

Notes: All four provinces are not normal due to the kurtosis

Table 2: ADF test statistic of rice yield data

Indexes	ADF Test statistic	Critical value at 1%	P-value
Punjab	-8.128*	-3.552	0.000
Sindh	-9.372*	-3.548	0.000
Khyber P.K	-6.345*	-3.560	0.000
Balochistan	-7.839*	-3.552	0.000

Notes: ADF test indicates that all the four variables are stationary.

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Table 3: Estimates of parameters of rice yield in Pakistan

Variables	Constant	AR(1)	AR(2)	MA(1)
Punjab	0.0294 (0.0589)	-0.1706 (0.1404)	-0.0512 (0.1393)	-0.9604 (0.0283)*
Sindh	0.0036 (0.0706)	-0.2092 (0.1322)	----	-0.9695 (0.0219)*
Khyber P.K	-0.0428 (0.0719)	-0.2801 (0.1480)	-0.0893 (0.1475)	-0.9568 (0.0202)*
Balochistan	-0.0192 (0.3398)	-0.3943 (0.1309)*	-0.1187 (0.0864)	-1.2257 (0.1341)*

Notes: Standard errors are in parentheses

Table 4: ARCH family Models for volatility in all four provinces of Pakistan

GARCH Model	α_o	α_1	β_1
Punjab	-0.0024 (0.2123)	-0.0891 (0.0193)*	1.1276 (0.0090)*
Sindh	35.328 (22.495)	0.816 (0.529)	-0.025 (0.142)
Khyber P.K	-0.9711 (1.0526)	-0.0109 (0.1432)	1.1152 (0.1743)*
Balochistan	1454.817 (984.7112)	0.1828 (0.1301)	-0.9916 (0.0014)*

Notes: Standard errors are in parentheses

Table 5: Forecast performance of rice yield in Pakistan

Forecasting Measures	Punjab	Sindh	Khyber P.K	Balochistan
Akaike information criteria (AIC)	**6.7482**	7.2541	6.8112	8.8635
Schwarz information criteria(SIC)	**7.0324**	7.5006	7.0954	9.1477

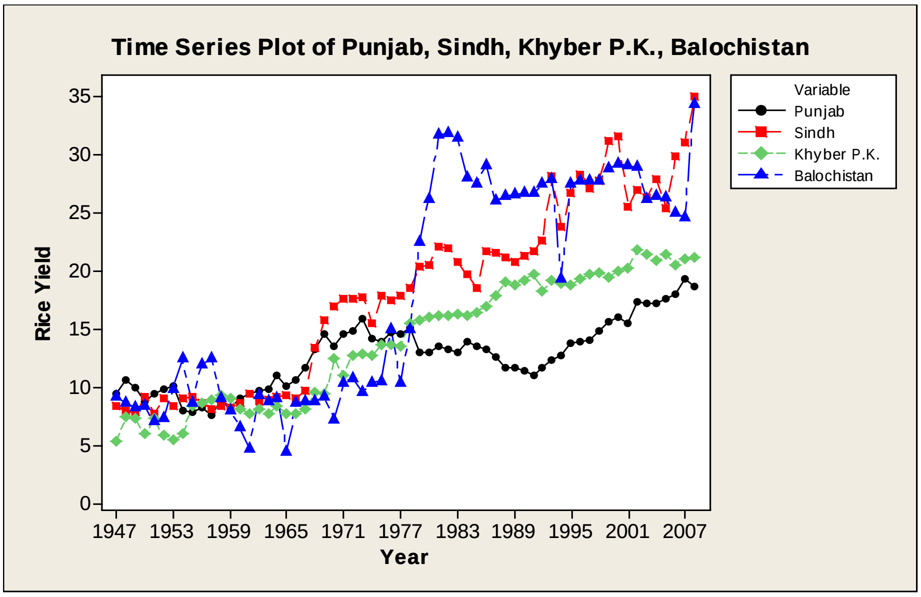

Figure 1: Time series plot of rice yield in Pakistan

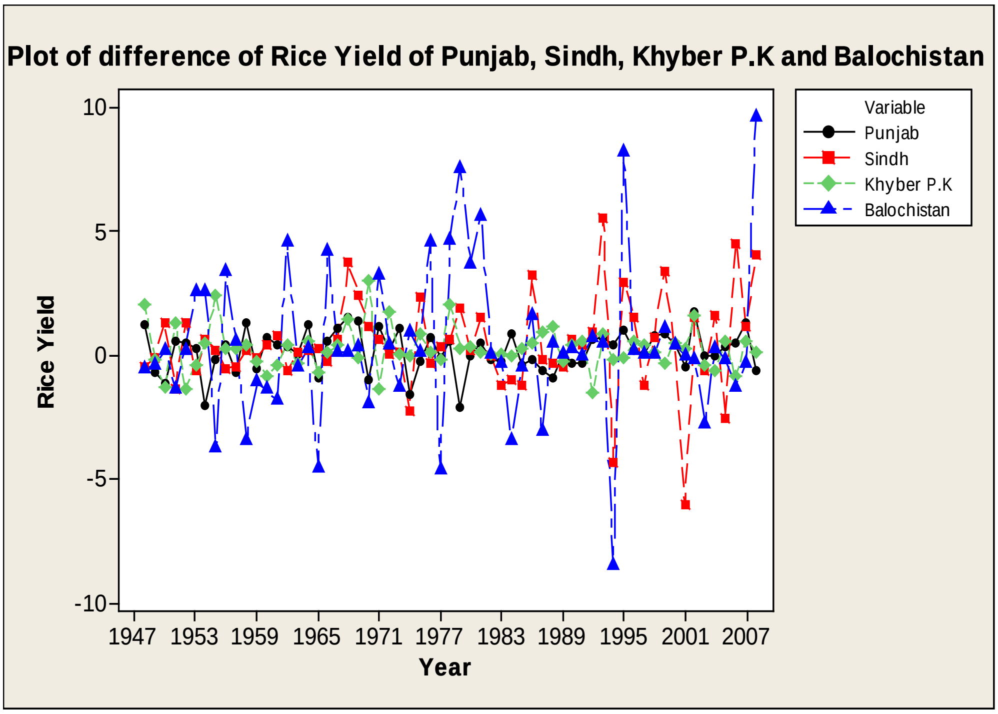

Figure 2: Time series plot of first difference of rice yield in Pakistan