Plant Archives Vol. 25, No. 1, 2025 pp. 149-152 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.1.022

ANALYSIS OF PRICE VOLATILITY OF MAJOR CEREALS CROPS IN KARNATAKA BY GARCH (GENERALIZED AUTOREGRESSIVE CONDITIONAL HETEROSCEDASTICITY) MODEL

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(Date of Receiving 28-06-2024; Date of Acceptance-01-09-2024)

ABSTRACT

Cereals, which serve as the primary staple food, occupy about 80 percent of the cropped area in India. Although India stands as the world's largest producer of cereals, the growth in cereal production has been sluggish over the years. This slow growth, combined with significant production fluctuations, has led to underperformance in the cereal sector and has contributed to substantial price variability, a major concern for policymakers. This study analyses the price volatility of key cereals—Paddy, Ragi, Jowar, Bajra, and Maize—in Karnataka using the GARCH model. The findings reveal that current price volatility is influenced by volatility from the previous period, as shown by the significant ARCH term for all the cereals studied. Furthermore, the sum of the á and â coefficients, which exceeds one at 1.162 during the study period, suggests an explosive price series with a tendency to drift away from the mean value. Consequently, there is a critical need for continuous price monitoring and timely government intervention to promote the sustainable development of the cereal sector.

***Key words*:** Cereals, ARCH, GARCH and Heteroscedasticity test.

Introduction

In India, agriculture sector be the significant factor for socio economic development of the country with two third populations depend on agriculture sector contributes about 19.23 per cent of the GVA during 2022-23 (Anonymous, 2022). The agricultural sector has significant influence on lower income and poor and vulnerable sections of the society in the country. However, the agriculture production does not match with demand and productivity is not at par with other developed countries due to various reasons like resources degradations, decline in public investment and technological fatigue and groundwater depletions (Mythili, 2001).

The demand for food grains is increasing at an increasing rate perhaps due to increase in the disposable income, change in the consumption pattern and burgeoning population and the rise of demand in rural areas because of huge public expenditure on government related schemes (MGNREGA, PMKY) further amounted pressures on prices of agricultural commodities. These factors increased demand significantly without making much contribution to supply side(Apum,2023). Hence, in recent period excessive price fluctuations among food commodities particularly cereals in the India and particularly in Karnataka state generate a situation of uncertainty that have a significant impact on the food supply chain, investments, and social development (OECD, 2010). In recent period cereal prices have increased close to a nine-year high in 2021 with tight global supply combined with strong demand and trade policy uncertainties which results into escalated the average wheat and other coarse grains prices by about 30% compared to last year. (FAO, 2022). The cereals

are substitutes for proteins (milk and egg, fish and meat and Cereals). In other words, when prices of proteins rise while foods budgets stay unchanged, consumption is switched to cereals and related products. The cereals-based prices play a vital role in the agricultural sector and influence on cropping area and marketing decision in turn determine the farm income and farmers standard of living in rural areas. The excessive price fluctuations in food commodities generate a situation of uncertainty that have a significant impact on food supply chain, investments and social development and deters required development investment in agriculture by increasing financial risks and uncertainty for producers and merchants.

The agriculture sector in the state of Karnataka forms the backbone for the economic development and contributes about 37.23 percent of the total State Domestic Product. The gross cropped area accounts gross cropped area 121.61 lakh ha (64% of the geographical area) area. The prominent cereals crop in the state are Rice, Ragi, and Jowar, maize accountsabout 35 per cent of the gross cropped of the state. However, the state experiences varying climatic conditions of arid, semi-arid and humid and second drought state next only to Rajasthan state. In the state, the food crops share an area of 65.63 per cent of the total cultivated area while remaining 34.32 per cent of the cropped area was shared by non-food crops. As per the year 2022-23 estimates, the state has large arable area under different cereals crops of paddy area with an area of 1.39 millionha, ragi area of 0.84 millionha, jowar area of 0.62 million ha and maize area of 1.59 million hectare as indicated in the table1. (DES, GoI, 2023).

In the state, rural household spend up to two-thirds of their income on food expenditure, the price volatility is a greater threat to the global growth and social stability (Surabhi, *et al.*, 2018). The price volatility or explosive are problematic when they are substantial and unpredictable, resulting in a high level of uncertainty. This in turn would increase risk for producers, traders, consumers including government, making all decisions sub-optimal. Food price volatility must be supervised regularly in order to formulate policies forfood and nutritional security in the state (OECD, 2010). Hence this motive to examine the price volatility among major cereal crops in the state. The findings of this study help to frame policies which sustainable agricultural production in the state.

Materials and Methods

The state of Karnataka is the major producer of cereals in India. The important cereals crops are paddy, ragi, maize and jowar inthe state. This study was conducted for these fourcereals crops individually and cereals as a group. The study was based on data extracted from secondary sources. Data on monthly and yearly wholesale price indices of cereals was retrieved from the Directorate of Marketing and inspection (DMI), Ministry of Agriculture and farmer's welfare, GoI (*https://agmarknet.gov.in*) for the period 1998-99 to 2022-23. In present study, compound annual growth rate an exponential function in the following form was employed for this analysis.

$$\mathbf{Y = a\, b^{t}} \quad \mathbf{(1)}$$

Where,

Y = Area / Production /Yield

a = Intercept

b = Regression coefficient ('a' and 'b' are the parameters to be estimated)

The equation (1) was transformed into log-linear form and written as;

$$\mathbf{\log Y = \log a + t \log b} \quad \mathbf{(2)}$$

Equation (2) was estimated by using Ordinary Least Squares (OLS)technique.

Compound growth rate (g) was then computed as;

$$\mathbf{g = (b - 1) \times 100} \quad \mathbf{(3)}$$

Where,

g: Compound growth rate in (%) per annum

b: Antilog of log b.

Furthermore, the price volatility of Cereals crops was analyzed using the Autoregressive Conditional Heteroscedasticity (ARCH) and Generalized Autoregressive Conditional Heteroscedasticity (GARCH) models. The ARCH model demonstrates the conditional variance as the square of the function of the previous error term, assuming the unconditional variance to be constant (Hamilton, 2018).

The basic form of the ARCH model as follows:

$$\mathbf{Y_t = \beta_0 + \beta_1 X_t + e_t} \quad \mathbf{(4)}$$

Where,

Y_t is the dependent variable;

X_t is an independent variable

β_0 and β_1 are parameters to be estimated

e_t is the error variable

In general, time series data tends to have a constant error term, known as homoscedasticity. However, high volatility in time series data can lead to non-constant residual variance, varying from one period to another, introducing an element of heteroscedasticity. Heteroscedasticity allows the conditional variance to change over time as a function of squared past errors, while maintaining a constant unconditional variance.

Table 1: The percentage share of area and production state to India in 2023.

S. No	Crops	Karnataka state				India	
		Area	% Of India level	Production	% Of India level	Area	Production
1	Paddy	1.39	3.00	1.12	0.87	46.28	129.47
2	Ragi	0.84	68.94	1.12	65.84	1.22	1.70
3	Jowar	0.62	16.36	0.75	17.75	3.81	4.23
4	Bajra	0.15	2.19	0.17	1.77	6.70	9.62
5	Maize	1.59	15.87	5.22	15.53	10.04	33.62
Source: *DES, GoI, 2023*							

Table 2: Compound Growth Rates in Area, Production, and Productivity major Cereals in Karnataka (in Percent).

Crops	Area	Production	Productivity
Paddy	2.57**	2.63**	2.35**
Ragi	1.75	1.94**	1.83
Maize	3.39**	4.41**	2.32**
Jowar	2.09**	1.23**	1.56**
Total Cereals	2.24**	2.45**	2.25**
*Note: ** significant at 5 per cent level of significance*			

The GARCH (Generalized Autoregressive Conditional Heteroscedasticity) model, an extension of the ARCH model (Bollerslev, 1986) addresses the assumption that unconditional variance is constant. The GARCH model posits that the variance of the disturbance variable is influenced not only by the disturbance variable in the previous period but also by the variance of the interruption variable in the previous period.

The equation for the variance of the interference variable with the GARCH model expressed as follows:

$$h_t = K + \delta_1 h_{t-1} + \delta_2 h_{t-2} + \ldots + \delta_r h_{t-r} + \alpha_1 \varepsilon^2_{t-1} + \alpha_2 \varepsilon^2_{t-2} + \ldots + \alpha_m \varepsilon^2_{t-m} \quad (5)$$

Where,

h_t = price variable of selected crops at time 't' or the variance at time 't'

K = constant variance

ε^2_{t-m} = ARCH term or volatility in the previous period

α_1, α_2, α_m=estimated order m coefficients

δ_1, δ_2, δ_r = estimated order r coefficients

h_{t-r} = GARCH term or variance in the previous period.

Table 3: Estimates of unit root test for monthly wholesale price.

Crops	Level		I st difference	
	t - statistics	p- value	t- statistics	p - value
Paddy	-1.51	0.519	- 2.68	< 0.001
Ragi	-2.73	0.719	- 1.87	< 0.001
Maize	-3.47	0.796	- 3.11	<0.001
Jowar	-1.19	0.664	- 2.77	< 0.001
Total Cereals	-1.83	0.697	- 1.56	< 0.001

GARCH (1,3) model has been used to get the volatility estimates. ARCH model helps in getting more efficient estimators by handling the heteroskedasticity in the errors properly. GARCH is the generalized ARCH (Chand *et al.*, 2012).

Results and Discussion

The Compound Annual Growth Rate (CAGR) in the area, production, and productivity of major cereals in the state of Karnataka is presented in Table 2. During study period there was significant and growth rate of area, production and productivity. The significant growth in the area has been achieved in paddy (2.57) Maize (3.39) Jowar (2.09) and total cereals (2.24) at 5 percent level of significance however ragi (1.75)non-significant whilst with respect to production there is significant improvement in cereals production in the study period. This might be due to introduction of new varieties, adoption of improved agricultural practices and National Food Security Mission (NFSM). However barring ragi crop all the cereals have significantly increased their productivity level.

To examine the price volatility among the Cerealsin Karnataka state through GARCH and ARCH model. Before this, first unit root attributes of the data series were estimated through unit root test by using Phillips-Peron (PP) test since the time series analysis is based on

Table 3: Heteroscedasticity test.

Crops	Obs. R- Square[a]	Prob.Chi-square[b]
Paddy	110.16	< 0.001
Ragi	93.63	< 0.001
Maize	13.65	< 0.001
Jowar	113.98	< 0.001
Note: H_0: There is no arch effect. **a:** no of observations times the R^2 from the test regression and; **b:** distribution of test statistics.		

Table 5: Price volatility estimation by ARCH and GARCH models for Cereals crops.

Crops	ARCH (α)	GARCH (β)	Sum (α + β)
Paddy	0.131**	0.034	0.165
Ragi	0.488**	0.416	0.904
Maize	0.331**	0.831	1.162
Jowar	0.342	0.121**	0.463

the assumption of stationary nature of data series since the PP test is based on non-parametric transformation of model to capture serial correlation in the error term. The unit root test results have failed to reject the null hypothesis of unit root in the series at 5 per cent level of significance for selected cereals crops as indicated by the p value of more than 0.05 in the study period. Hence, reveals that presence of unit root in the data series implying that the price series of selected cerealsare non-stationary in nature at the level. However, by taking I difference of price series, the test results were found highly significant at 1 per cent level of significance. Thus, it confirms Cerealsprice series are stationary at first difference level in the study period as indicated in the Table 3.

Once the confirming of the data stationary series, The ARCH-LM Heteroscedasticity test was employed in order to identify the ARCH effect in data residuals. The ARCH-LM test performs as auxiliary regression by using the residuals from the original equation estimated. The test results presented in Table 4 reject the null hypothesis of no ARCH effect for all the Cereals crops and hence confirming the presence of ARCH effect in the price series of all the selected Cereals crops.

The Price volatility estimation by ARCH and GARCH models for Cereals crops indicated in the Table 5 after confirming the stationary of data series. However, later ARCH-LM heteroscedasticity test confirms that no ARCH effect for all selected Cereals crops. Therefore, the GARCH model was employed to capture volatility in data. Amongst the different GARCH models, the GARCH (1,3) was considered as most appropriate model and the result of the fitted model is given in Table 3. The findings of the GARCH analysis clearly indicate that the volatility in the current period depends on basis of volatility in the preceding period of the price of crops. In case of Cereals as evident from the significant ARCH term for all the crops in both the periods.

The ARCH (α) coefficient of paddy and ragi was 0.131 and 0.488 significant at 5 percent level of significance respectively indicating a moderate autoregressive component and suggesting a moderate level of persistence in volatility. The GARCH (β) value of jowar was 0.121 and significant at 5 percent level of significance, signifying a moderate impact of past squared returns on current volatility. The sum of α and β coefficients near to one indicates the degree of persistence of volatility in the cerealsprice series (Gil-Alana and Tripathy, 2014). However, it was found more than one for maize crop with 1.162 in study period thus indicating an explosive price series with a tendency to meander away from mean value. It implies that the shocks in prices of maize crop persist forever and do not reverse to the mean.

Conclusion

The Karnataka state is one of the major producing states of cereals crop in India and in the recent period high Price volatility in the Cereals crops discourage farmers to take up improved production and plant protection methods leading to low production and instability in farmer's income. The present study examines the cereals price volatility through in study period thus indicating an explosive price series with a tendency to meander away from mean value. It implies that the shocks in prices of maize crop persist forever and do not reverse to the mean this mainly due positive shock in the supply and huge demand from the poultry sector and speculative trading practice. Therefore, regular monitoring of prices particularly Cereals crops and networking of farmers for providing better market information on prices and institutional interventions by the state governments enables sustainable development of cereals sector in the country.

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