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ESTIMATING THE PRICE VOLATILITY OF MAJOR PULSE CROPS IN KARNATAKA BY GARCH(GENERALIZED AUTOREGRESSIVE CONDITIONAL HETEROSCEDASTICITY) MODEL

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ABSTRACT

India, despite being the world's largest producer of pulses, has witnessed only sluggish growth in pulse production over the years. This low growth rate, combined with significant fluctuations in production, has led to underperformance in the pulse sector and contributed to high price variability. Price volatility in pulses is a major concern for policymakers. This study estimates the price volatility of major pulses (chickpea, pigeon pea, black gram, green gram, and total pulses) in Karnataka using the GARCH model. The results indicate that current volatility is influenced by the volatility of the preceding period, as evidenced by the significant ARCH term for all selected pulse crops. Additionally, the sum of the α and β coefficients exceeding one for pigeon pea (1.624) and green gram (1.081) barring chickpea (0.235) and black gram (0.441) in study period suggests an explosive pattern with a tendency to deviate from the mean value. The price series for pigeon pea and green gram, in particular, has shown more persistent and explosive volatility in recent periods. Therefore, there is a pressing need for regular price monitoring and timely government interventions to ensure the sustainable development of the pulse sector.

***Key words*:** price volatility, GARCH, pigeon pea, persistent and explosive volatility

Introduction

The agricultural 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 agricultural price is usually determined by market forces (demand and supply) in the market and determines the best price (Norwood *et al.*, 2021). But this founds theory rarely happens in the country like India. In India, generally the market imperfections can create distortions in functioning of the market and greater influence in the price by altering the supply. The prices are mainly controlled by the commission agents and traders who dominate in the wholesale market both as buyers and sellers. Since they act as both oligopolists and oligopsonists, which creates the bottleneck in the marketing process (Kreutzer, 2023).

The market imperfections can influence the price temporarily but the prices fluctuations cannot sustain for longer period unless there is no artificial scarcity and also seasonal variations in the commodity prices. The commodity prices are lower particularly during the harvesting time and crop price escalates during the lean season. In India, the agriculture production does not match with demand and productivity is not atpar 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 have shown paramount pressures on the commodity prices especially for pulses, vegetables, eggs, fish, meat products and vegetables showing consumption pattern shifts from cereals based to protein bases because of rise in the income level. Furthermore, 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).

In India, the improvement in the terms of trade for agriculture sector after 2004-05 was mainly attributed due to prices rather than non-farm commodities (Chand and Parappurathu, 2012). In recent years food prices particularly, pulses have exhibited extreme instability in agricultural commodities. The spike in pulses price affects consumption and has ramifications for nutritional security of the people since pulses making them important both economically as well as nutritionally. Pulses provides protein and fibre, and significant source of vitamins and minerals (iron, zinc, folate, and magnesium) and the consumption of half a cup of beans or peas per day can enhance diet quality by increasing intakes of these nutrients. Pulses are high in fibre and have a low glycaemic index, making them particularly beneficial to people with diabetes by assisting in maintaining healthy blood glucose and insulin levels. The instability in pulses prices may distort production and investment decisions which results into inefficient allocations of resources. The flow of information at one level in the marketing chain gets transmitted through price changes at other levels in the chain.

The India is the largest pulse producing country in the world, the production of these crops in the country has shown sluggish growth over the years (Bisht, 2018). The stagnant production along with accelerating demand is leading to a decline in per capita availability of pulses and a spiral in prices. In Karnataka state accounts of 31.21 lakhs hectare with production of about 19.45 lakh tons and contributes about 8 percent to total production of India during 2023 (DES, GoI, 2022). Despite this, gap between demand and supply of pulses is widening and about 20 percent of their total demand is yet met by imports. The stable price environment for growers is very significant in scaling up of the agricultural production and productivity (Singh *et al.*, 2015). The market pulse price tends to be unstable and volatile in many times results into suboptimal outcomes relatively with those attained during stabilised price conditions. The common perception or arguments among the economists that price transmission in agricultural markets is asymmetric in nature, due this neither farmershare benefited because of higher price nor consumers. Due to price volatility producers and consumers have greater detrimental effects which may reduce investments and access to nutritious food respectively but also be negative macroeconomic impacts due to declining in the total investment which may also have effects on poverty and food security. Therefore, it is need of the hour to examine price volatility of pulses in Karnataka. The findings of this study help to policy makers, administrators, researchers and farmers. The tailored price policy is likely to accelerate and sustain the growth of pulse output by protecting the interest of the farmers on a long-term basis particularly in respect of deficit commodities such as pulses.

Materials and Methods

The state of Karnataka is the major producer and accounts of 8 per cent of India total productionchickpea, pigeon pea, black gram and green gram are the major pulses grown and consumed in state. This study was conducted for these four pulse crops individually and pulses as a group. The study was based on data extracted from secondary sources. Data on monthly and yearly wholesale price indices of pulses was retrieved from the website of Ministry of Commerce and Industry (www.eaindustry.nic.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.

$$Y = ab^{t} \quad (1)$$

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;

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

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

Compound growth rate (g) was then computed as;

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

Where,

g: Compound growth rate in (%) per annum

Table 1: Compound Growth Rates in Area, Production, and Productivity major pulse in Karnataka (in Percent).

Crops	Area	Production	Productivity
chick pea	2.15**	2.632**	2.14 NS
pigeon pea	1.65	1.74**	1.63 NS
black gram	3.23	2.41	1.16
green gram	2.32**	1.43**	1.34 NS
total pulses	1.36	1.57	1.75
*Note: ** significant at 5 per cent level of significance*			

b: Antilog of log b.

Furthermore, the price volatility of pulse 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:

$$Y_t = \beta_0 + \beta_1 X_t + e_t$$

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.

The GARCH (Generalized Autoregressive Conditional Heteroscedasticity) model, an extension of the ARCH model (Bollerslev, 1986) addresses the assumption that unconditional variance is constant. The

Table 2: Estimates of unit root test for monthly wholesale price.

Crops	Level		I st difference	
	t - statistics	p- value	t- statistics	p - value
chick pea	-1.45	0.546	-3.657	< 0.001
pigeon pea	-2.45	0.768	-4.873	< 0.001
black gram	-3.43	0.876	-3.123	<0.001
green gram	-1.87	0.654	-2.674	< 0.001
Total pulses	-2.23	0.676	-2.34	< 0.001

Table 3: Heteroscedasticity test.

Crops	Obs. R- Square[a]	Prob.Chi-square[b]
chick pea	112.36	< 0.001
pigeon pea	85.63	< 0.002
black gram	24.65	< 0.003
green gram	120.98	< 0.004
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.		

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:

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

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.

GARCH (2,1) 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 Discussions

The Compound Annual Growth Rate (CAGR) in the area, production, and productivity of major pulse in the state of Karnataka is presented in Table 1. During study period there was significant and positive growth rate of area, production and non-significant in productivity. The significant growth in the area has been achieved in chick pea (2.15) and green gram (2.32) with 5 percent level of significance whilst with respect to production; the pulse crops like chickpea (2.63), pigeon pea (1.74) and green

Table 4: Price volatility estimation by ARCH and GARCH models for pulse crops.

Crops	ARCH (α)	GARCH (β)	Sum (α + β)
chick pea	0.221**	0.014	0.235
pigeon pea	0.798	0.826**	1.624
black gram	0.37**	0.71**	0.441
green gram	0.47	0.611	1.081

gram (1.43) have significant improvement in pulse 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).

In order to examine the price volatility among the pulses in 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 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 pulse 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 pulses are 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 pulse price series are stationary at first difference level in the study period as indicated in the Table 2.

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 3 reject the null hypothesis of no ARCH effect for all the pulse crops and hence confirming the presence of ARCH effect in the price series of all the selected pulse crops.

The Price volatility estimation by ARCH and GARCH models for pulse crops indicated in the Table 4 after confirming the stationary of data series. However, later on ARCH-LM heteroscedasticity test confirms that no ARCH effect for all selected pulse crops. Therefore, the GARCH model was employed to capture volatility in data. Amongst the different GARCH models, the GARCH (2, 1) 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 pulses as evident from the significant ARCH term for all the crops in both the periods. The ARCH (α) coefficient of chick pea and black gram was 0.221 and 0.37 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 pigeon pea and black gram was 0.82 and 0.71 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 pulse price series (Bisht and Kumar, 2019, Gil-Alana, L.A. and Tripathy, T. 2014). However, it was found more than one for pigeon pea (1.624) and green gram (1.081) barring chickpea (0.235) and black gram (0.441) 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 pigeon pea and green gram persist forever and do not reverse to the mean.

Conclusion

The Karnataka state is one of the major producing states of pulse crop in India with 8 percent in total production, however due to climatic vagaries production of these pulse crop becomes stagnant in recent period. As consequences of this, there is wide gap between the demand and supply in pulse sector and results into high price variability. The high Price volatility in the pulse 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 pulse price volatility through GARCH (2,1) model it was found more than one for pigeon pea (1.624) and green gram (1.081) barring chick pea (0.235) and black gram (0.441) 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 pigeon pea and green gram persist forever and do not reverse to the mean this mainly due positive shock in the supply and monopolistic behaviour of traders, artificial scarcity by traders, speculative trading practice. Therefore, regular monitoring of prices particularly pulse crops and networking of farmers for providing better market information on prices and institutional interventions by the state governments enables sustainable development of pulse sector in the country.

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