

Estimating Volatility in Prices of Pulses in India: An Application of Garch Model

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ABSTRACT

Although, 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. Low growth rate coupled with high fluctuations in production of pulses is mainly responsible for poor performance of pulse sector. It also leads to high price variability. Variability in the prices of pulses is a major concern for decision makers. This study was conducted to estimate the volatility in the prices of major pulses (chickpea, pigeonpea, blackgram, greengram and lentil) in India using GARCH model. Results have shown that the volatility in the current period depends on volatility in the preceding period in case of pulses as evident from the significant ARCH term for all the crops. Further, the sum of α and β coefficients has been found more than one for all the pulse crops except pigeonpea in period I thus indicating an explosive price series with a tendency to meander away from mean value. The volatility in the price series of pigeonpea has been found more persistent and explosive in recent period. So, there is a need for regular monitoring of prices and appropriate interventions by the government, when necessary, to make the development of pulse sector more sustainable.

Highlights

- The prices of pulses were found highly volatile and this volatility was persistence and do not reverse to mean with time.

Keywords: Pulses, Price Volatility, GARCH model

Pulses serve as a cost-effective and nutritionally balanced rich source of protein to the people of India who are predominantly vegetarian in dietary habits, thereby, forming an important constituent of the food basket. The potential of pulses to help address future global food and nutritional security and environmental sustainability needs has been acknowledged through the UN declaration of the 2016 as 'International Year of Pulses'. India is the major producer, consumer and importer of pulses in the world. India produced 17.15 million tonnes of pulses from an area of 23.55 million hectare in the year 2014-15 with an average productivity of 728 kg per ha. India produces around 25 per cent of global pulse production from around 35 per cent

of global area and productivity of 659 kg per ha. Chickpea, pigeonpea, blackgram, greengram and lentil are the major pulses grown and consumed in India occupying nearly 84 per cent of the area under pulses and accounting for about 85 per cent of pulse production in the country. Among the various pulses, chickpea dominates, claiming a more than 40 per cent share in production of all pulses grown. Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh and Karnataka are the top five pulses producing states sharing 68 per cent of total pulse production in India. Pulses account for around 20 per cent of the area under foodgrains and contribute around 7 per cent of the total foodgrains production in India (GoI, 2016).

Although, 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. The gap between demand and supply of pulses is widening and about 20 per cent of their total demand is yet met by imports. Assurance of stable price environment for growers is very important for increasing agricultural production and productivity. The market price for agricultural produce many a times tends to be unstable and volatile which may lead to suboptimal outcomes compared with those attained under stabilised price conditions. For producers, price volatility may reduce investments and cause production to shift toward lower-risk. Consumers are also negatively affected by the price volatility because of reduced or uncertain access to food. There may also be negative macroeconomic impacts, such as balance of payment, public deficits, and declining total investment because of uncertainty all of which may also have second-round effects on poverty and food security. Therefore, it is imperative to investigate the issues of price volatility that would help policy makers to formulate suitable price policy. A suitable price policy is likely to accelerate and sustain the growth of output by protecting the interest of the farmers on a long-term basis particularly in respect of deficit commodities such as pulses. The objective of our study was to examine the volatility in the prices of major pulses and pulses as a group over time.

DATABASE AND METHODOLOGY

India is the major producer, consumer and importer of pulses in the world. Chickpea, pigeonpea, blackgram, greengram and lentil are the major pulses grown and consumed in India that account for nearly 80 per cent of total pulse production. This study was conducted for these five 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 1996-97 to 2016-17. This period has been further divided into two sub periods viz., Period I (1996-97 to 2006-07)

and Period II (2007-08 to 2016-17). Volatility is the sudden unexpected rise or fall in the series. There are various ways of measuring price volatility. In present study, GARCH (1,1) 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. This model was used in earlier studies also to estimate volatility (Upreti 2015; Anuja *et al.* 2013; Bhardwaj *et al.* 2014). The (1, 1) in GARCH (1, 1) refers to the presence of a first-order autoregressive GARCH term (the first term in parenthesis) and a first-order moving average ARCH term (the second term in parenthesis). The Garch (1, 1) model is expressed by the following equation:

$$Y_{it} = a_0 + b_1 Y_{i,t-1} + b_2 Y_{i,t-2} + e_{it} \quad \dots(1)$$

Where,

Y_{it} = price index in time t of crop i .

t = time which takes value 1, 2,.....,T

It is the mean equation written as a function of exogenous variables with an error term.

$$\sigma_{it}^2 = \alpha_0 + \alpha_i u_{i,t}^2 + \beta_i \sigma_{i,t-1}^2 \quad \dots(2)$$

Where, σ_{it}^2 denotes the variance of e_t conditional upon information up to period $t-1$. Since σ_{it}^2 is the one-period ahead forecast variance based on past information, it is called the *conditional variance*. The conditional variance equation is a function of three terms:

- ◆ A constant term.
- ◆ Information about volatility from the previous period, measured as the lag of the squared residual from the mean equation: (the ARCH term).
- ◆ Last period's forecast variance: (the GARCH term).

The fitted values of σ_{it}^2 give the measure of uncertainty of Y_{it} . The sum of $\alpha_i + \beta_i$ gives the degree of persistence of volatility in the series. The closer the sum to 1, greater is the tendency of volatility to persist for longer time. If the sum exceeds 1, it is indicative of an explosive series with a tendency to meander away from mean value.

RESULTS AND DISCUSSION

To run the GARCH model, first unit root properties of the series were estimated as time series analysis is based on the assumption of stationary nature of series. For testing the same, unit root test was done on price series using Phillips-Peron (PP) test. PP test is based on nonparametric transformation of model to capture serial correlation in the error term. The results are given in Table 1. The test results have failed to reject the null hypothesis of unit root in the series at 5 per cent level of significance for all the pulse crops (Table 1) as indicated by the p-value of more than 0.05 for all the pulses in both the periods. Thus, it confirms the presence of unit root in the series implying that the price series of pulses are non stationary in nature at level. But by taking 1st difference of price series, the test results were found highly significant at 1 per cent level of significance. Thus, it confirms the stationary of price series at their first difference for all the pulse crops.

Table 1: Results of unit root test for monthly wholesale price indices of pulses

Crops	Period	PP test			
		Level		1 st Difference	
		t-statistics	p-value	t-statistics	p-value
Chickpea	Period I	-1.397	0.5821	-4.345	<0.001
	Period II	-1.095	0.7164	-5.405	<0.001
Pigeonpea	Period I	-2.213	0.2028	-6.731	<0.001
	Period II	-1.724	0.4168	-6.531	<0.001
Blackgram	Period I	-0.507	0.8851	-8.777	<0.001
	Period II	-1.100	0.7142	-4.326	<0.001
Greengram	Period I	1.206	0.9981	-9.626	<0.001
	Period II	-1.426	0.5675	-6.912	<0.001
Lentil	Period I	-1.812	0.3735	-7.659	<0.001
	Period II	-1.601	0.4748	-6.929	<0.001
Total Pulses	Period I	-0.053	0.9511	-6.712	<0.001
	Period II	-1.009	0.7485	-5.459	<0.001

Note: H_0 : Series has unit root.

After confirming the stationary of series, ARCH-LM Heteroscedasticity test was done for identification of ARCH effect in residuals. ARCH-LM test perform an auxiliary regression using the residuals from the original equation estimated. The test results presented in Table 2 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 pulse crops. Then, the GARCH model was employed to capture volatility in data.

Table 2: Results of heteroskedasticity test

Crops	Period I		Period II	
	Obs. R-square ^a	Prob. Chi-Square(1) ^b	Obs. R-squared	Prob. Chi-Square(1)
Chickpea	117.845	<0.001	100.932	<0.001
Pigeonpea	97.530	<0.001	111.606	<0.001
Blackgram	118.027	<0.001	108.830	<0.001
Greengram	121.692	<0.001	111.171	<0.001
Lentil	100.659	<0.001	110.125	<0.001
Total Pulses	121.652	<0.001	107.399	<0.001

Note: H_0 : there is no arch effect.

^ano of observations times the R^2 from the test regression; ^bdistribution of test statistics.

GARCH (1,1) was selected as the most appropriate model and the summary of the fitted model is given in Table 3. The results of the GARCH analysis clearly indicate that the volatility in the current period depends on volatility in the preceding period in case of pulses as evident from the significant ARCH term for all the crops in both the periods. The sum of α and β coefficients near to one represents the degree of persistence of volatility in the price series but it was found more than one for all the pulse crops except pigeonpea in period I thus indicating an explosive price series with a tendency to meander away from mean value. It implies that the shocks in prices of pulses persist forever and do not reverse to the mean.

Gil-Alana (2014) also found that shocks have a permanent nature in case of arhar and urad as compared to cereals. The Table 3 further shows that the value of $\alpha+\beta$ in case of pigeonpea was 0.86 in sub period I that is near to one indicating that shocks die out rather slowly. It means that shocks to the prices of pigeonpea had the tendency to persist for a longer period but they tend to reverse to the mean in sub period I. This sum has increased to more than one in sub period II indicating the explosive nature of pigeonpea prices in recent period. The sum of $\alpha+\beta$ was found higher for chickpea and pigeonpea in sub period II as compared to sub period I which indicates more explosive price series in recent period compared to the instant past period particularly for pigeonpea.

Table 3: Parameter estimates of GARCH model

Crops	Period I			Period II		
	ARCH(α)	GARCH(β)	$\alpha+\beta$	ARCH(α)	GARCH(β)	$\alpha+\beta$
Chickpea	0.995*	0.124	1.119	1.340*	-0.217**	1.123
Pigeonpea	1.235*	-0.375*	0.860	1.187*	-0.006	1.181
Blackgram	1.311*	-0.203*	1.108	0.760**	0.337*	1.097
Greengram	1.155**	-0.068	1.087	1.013**	0.015	1.028
Lentil	0.666**	0.395*	1.061	1.070*	-0.028	1.042
Total Pulses	1.145*	-0.119***	1.026	1.219**	-0.097*	1.122

*, **, *** indicates significant at 1, 5 and 10 per cent level of significance.

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CONCLUSION

Although, 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. Low growth rate coupled with high fluctuations in production of pulses is mainly responsible for poor performance of pulse sector. It also leads to high price variability. Variability in the prices of pulses is a major concern for decision makers. Price volatility discourage farmers to take up improved production and plant protection methods leading to low production and instability in farmer's income. Price policy in developing countries like India plays an important role in decision making where the agricultural markets have the overarching government presence. The volatility as captured by GARCH (1,1) model was found more than one for all the pulses except pigeonpea in period I thus indicating an explosive series with a tendency to meander away from mean value. This volatility in prices of pulses has increased in sub period II. This implies that the shocks in price system are permanent in nature in case of pulses and do not reverse to the mean over the time. The high volatility largely occurs due to supply shortage, monopolistic behaviour of traders,

increase in profit margins, information gap and weak infrastructure. So, there is a need for regular monitoring of prices and appropriate interventions by the government, when necessary, to make the development of pulse sector more sustainable. More researches are needed for proper understanding of agricultural price mechanism specifically in pulses that would help farmers to plan the production and marketing for improved farm profit. There is also a need to study marketing and market infrastructure for pulses in depth for better realisation by farmers and enhanced pulses production in the country.

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