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Modeling Volatility of Price of Agricultural Products in India: Using Arima-Garch Applications

KEYWORDS: Agricultural product price volatility, ARCH/GARCH models, forecasting

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ABSTRACT *This paper empirically investigates the nature of Agricultural product price volatility. Recent trends in international as well domestic agricultural markets and in the interest of analyzing, contributing to discussions of and making informed decisions on how to address the complex problem of price volatility. Price fluctuations are both a normal attribute and a necessary requisite for competitive market functioning Price volatility has assumed critical importance today in the context of agricultural into domestic markets. The Agriculture commodities selected for the study are Onion and Potato.*

Introduction
Price instability means lack of stability in prices. Instability in prices is defined as the state in which prices continue to change over time and space. Fluctuations in the prices are associated with varying lengths of time due to various factors. It clearly understands as to how the instability is related to measurement concept. Suppose prices in a country over the years rise at a constant rate of 6 percent, this is certainly a situation of unstable prices, but the direction and extent of price movement is measured and known with certainty. this means that there is no uncertainty element in the movement of price. Prices in general are volatile and in particular agricultural commodity prices are renowned for their continuously volatile nature. Volatility is the variability in the rates at which prices change over time. It relates to the speed, magnitude and direction of the rates of change in prices.

Considering changes in the price of agricultural commodities, one must distinguish between changes in trend and mere fluctuations (volatility). Changes in trend occur over medium- or long-term periods and are due to structural alterations in the factors affecting supply and demand. Managing price fluctuations in agricultural commodities within reasonable range has been one of the biggest concerns in domestic markets in india. Volatility in Agricultural, food prices, affects poor agricultural laborers and labour engaged in unorganized sector adversely because their wages are not index- linked with Inflation. Small farmers in India, with low propensity to save and poor access to efficient saving instruments cannot cope with the Revenue variability resulting from fluctuations in output prices. Food and agricultural commodity prices in India are primarily determined by domestic demand and supply factors influenced by domestic price policy. Inflation and price rise of food items have become a major concern for policy makers worldwide, In India Food inflation in India, measured by movement of wholesale and consumer prices indices, has been consistently increasing for last several years. Volatility refers to variations in economic variables over time. Specifically, in this case, volatility is a measure of price variation between periods for prices of agricultural commodities. If there is a large price variation between periods then we speak of large returns or large volatility.

Determinants of Agricultural product price volatility:
In India, domestic food prices are less volatile due to a more stable supply and more Regulated markets. But the main factors underlying the instability on domestic markets are

1) Supply-side variability due to the impact of natural factors (monsoon) on harvests.
2) The decrease in stocks' volumes.
3) unreliable linkages within the value chain- lack of storage facilities
4) The small Excess Agricultural product of marketed smallholder production.
5) Weak infrastructure

Selected Agriculture product under Study:
1) Onion: Onion is an important vegetable consumed all over the world .India is the second largest country producer in the world after china with over 15 million tones producer in year 2010-11 Onion is one of the most market sensitive commodities that create political circles. Among the agricultural products, prices of onions are more volatile

Onion is produced in the leading states of Maharashtra, Karnataka, Madhya Pradesh, Rajasthan, Gujarat, Andhra Pradesh and Bihar which around 70 percent of the area under onion. Maharashtra Is the leading state accounting for more than 30 per cent area. As Maharashtra is major state contributes to the total production (33 per cent)

Potato:
The potato is the third most Important Agriculture food product in world after wheat and rice.potato in india is considered as vegetable item it is a major food in indi its cultivated around 19 lakh hectors and its contributed around 2.42% of Agriculture GDP in 2008 .in India most leading producer states are Uttar Pradesh, west Bengal Bihar Punjab Gujarat,

OBJECTIVES:
The main objective of this paper is are following

1) To investigate the consistency onion and potato domestic Agricultural product price volatility of onion and potato.
2) To identify the Trend of domestic price volatility of onion and potato.
3) To analyze time series data on production and prices, onion and potato.

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4) To measure the degree of price instability of onion and potato agricultural commodities.

LITERATURE REVIEW:
Financial literature and has been recognized as one of the most important economic phenomena (Engle, 1982). Apergis and Rezitis (2011) noted that price volatility leads both producers and consumers to uncertainty and risk and thus volatility of commodity prices has been studied to some extent.Many alternative specifications to model conditional volatility are proposed in the literature, corresponding to a variety of different acronyms (see Bollerslev, Chou and Kroner, 1992; Bera and Higgins, 1993; Bollerslev, Engle and Nelson, 1994; or Diebold and Lopez, (1995)

METHODOLOGY:
The Present study, using monthly Agricultural product price data investigates variable than the domestic prices The Agriculture commodities selected for the study are Onion and Potato

DATA:
This study has taken from secondary source. The Monthly time series data used in this analysis consists of the monthly Agriculture commodity onion and potato prices products the period of analysis for data set is from January 2004 to July 2014. Giving a total of 127 observations. The prices are in under Study are: Onion, Data sources are given are RBI,FAO, and Indian Ministry of Agriculture websites, Agriculture Statistics at a Glance,, Handbook of Statistics on the Indian Economy, Fertilizer Statistics, Fertilizer Association of India,

TECHNIQUES:
ARCH and the GARCH models can estimate and forecast volatility of time series data, ARCH and GARCH models, which stand for autoregressive conditional heteroskedasticity and generalized autoregressive conditional heteroscedasticity, have become widespread tools for dealing with time series heteroskedasticity models.

The first ARCH Model was presented by Engle (1982). the model suggests that the variance of the residuals at time t depends on the squared error terms from past period. ARCH variations, extensions and applications than the generalized GARCH model include the lagged conditional variance terms as autoregressive terms. ARCH models are capable of modeling The serial correlation in squared returns, or conditional heteroskedasticity (volatility clustering), can be modeled using a simple autoregressive (AR) process for squared residuals. The aim of such models is to provide a volatility measure like a standard deviation that can be used in financial decisions concerning risk analysis, portfolio selection and derivative pricing. (Engle, 1982) Generalised Autoregressive Conditional Heteroscedasticity (GARCH) model (Bollerslev, 1986). model has been used in this study to examine price volatility. A GARCH (1, 1) model expressed as,

The ARCH Model
A basic ARCH specification is

$$y_t = \mu + \rho y_t + \epsilon_t$$
$$= gt + \epsilon_t$$
$$\epsilon_t = \sigma u_t$$
$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \epsilon_{t-i}^2$$

Where the u_t are Gaussian white noise process. The model is known as the auto regressive conditional heteroscedasticity (ARCH) model of Engle (1982). Which is usually referred to as the ARCH (p) model. The ARCH variance is a moving average process. Previous large shocks to the series cause the conditional variance of the series to increase. There is no leverage: negative shocks have the same impact on the future variance as do positive shocks.

For of to be positive for all realizations of (α_t), we need $\omega > 0$, $\alpha_i \geq \alpha_i$

testing of arch effect:
In order to test for the presence of ARCH effects in the residuals, were use AR representation of squared residuals in the following way construct an auxiliary regression.

$$\hat{u}_t^2 = \alpha_0 + \alpha_1 \hat{u}_{t-1}^2 + \dots + \alpha p \; \hat{u}_{t-p}^2 + u_t$$

The significance of parameters α_1 would indicate the presence of conditional volatility. Under the null hypothesis that there are no ARCH effect.

$$\alpha_1 = \alpha_2 = \dots = \alpha_p = 0$$

The test statistic , where T is the sample and R^2 is computed from the auxiliary regression.

The GARCH model
More general form of conditioinal volatility is based on ARMA specification as an extension of AR process of squared residuals. Bollershev (1986) introduces GARCH model which stands for generalized ARCH.

$$y_t = \mu + \rho y_t + \epsilon_t$$
$$= gt + \epsilon_t$$
$$\epsilon_t = \sigma u_t$$
$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i u_{t-i}^2 \quad \sum_{i=1}^{q} \beta_i \sigma_{t-j}^2$$

Where is the coefficients αi and βj are positive to ensure that the conditional variance is always positive in order to emphasize the number of lags used in model denoted the model by GARCH (p, q).

A GARH model can be expressed as ARMA model of squared residual a GARCH (1,1) model.

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta_1 \sigma_{t-1}^2$$

Usually the process looks stationary, means reverting and with 0 means as expected from GARCH (1,1) model.

Note that an ARCH model specifies the variance process as a moving average. For the same reason that an ARMA model may be used to parsimoniously model a series instead of a high order AR or MA, one can do the same thing for the variance series. The idea is that a GARCH model with low values of p and q may fit the data as well or better than an ARCH model with large q.

EMPIRICAL ANALYSIS:
Model 2: ARMAX, using observations 2004:01-2014:07 (T = 127)
Dependent variable: ONION___Rs__Qtl
Standard errors based on Hessian

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Table No.1.1

	Coefficient	Std. Error	z	p-value	
const	726.879	202.045	3.5976	0.00032	***
phi_1	0.768223	0.0603161	12.7366	<0.00001	***
theta_1	0.511202	0.0656587	7.7857	<0.00001	***
POTATO_ Rs__Qtl	0.334313	0.176361	1.8956	0.05801	*

Mean dependent var	934.9843	S.D. dependent var	662.1230
Mean of innovations	-0.159614	S.D. of innovations	278.1957
Log-likelihood	-895.9312	Akaike criterion	1801.862
Schwarz criterion	1816.083	Hannan-Quinn	1807.640

		Real	Imaginary	Modulus	Frequency
AR					
	Root 1	1.3017	0.0000	1.3017	0.0000
MA					
	Root 1	-1.9562	0.0000	1.9562	0.5000

All the lagged variance coefficients are positive, as expected; it seems there is an ARCH effect in the onion. That is, the error variances are autocorrelated. This information can be used for the purpose of forecasting volatility.

Model 3: ARMAX, using observations 2004:01-2014:07 (T = 127)
Dependent variable: POTATO_Rs__Qtl
Standard errors based on Hessian

Table No.1.2

	Coefficient	Std. Error	z	p-value	
const	621.552	88.8757	6.9935	<0.00001	***
phi_1	0.77638	0.0697791	11.1262	<0.00001	***
theta_1	0.406209	0.101826	3.9893	0.00007	***
ONION__ Rs__Qtl	0.097387	0.0454246	2.1439	0.03204	**

Mean dependent var	707.5433	S.D. dependent var	314.8400
Mean of innovations	1.378999	S.D. of innovations	142.2526
Log-likelihood	-810.6469	Akaike criterion	1631.294
Schwarz criterion	1645.515	Hannan-Quinn	1637.072

		Real	Imaginary	Modulus	Frequency
AR					
	Root 1	1.2880	0.0000	1.2880	0.0000
MA					
	Root 1	-2.4618	0.0000	2.4618	0.5000

All the coefficients of mean and variance equation are statistically significant at 3% and 2 % level of significance.

Value of test statistic is greater than the critical value from the Chi-square distribution indicates the evidence of ARCH(q) effects.

Test for ARCH of order 12 (Onion)
Table No.1.3

	Coefficient	Std. error	t-ratio	p-value
alpha(0)	62186.4	31720.5	1.960	0.0527 *
alpha(1)	0.182697	0.0993233	1.839	0.0688 *
alpha(2)	0.0876954	0.100917	0.8690	0.3869
alpha(3)	0.0421143	0.101278	0.4158	0.6784
alpha(4)	0.0276112	0.101363	0.2724	0.7859
alpha(5)	-0.00457146	0.101399	-0.04508	0.9641
alpha(6)	-0.0512703	0.101298	-0.5061	0.6139
alpha(7)	-0.0382481	0.101613	-0.3764	0.7074
alpha(8)	-0.00299546	0.102170	-0.02932	0.9767
alpha(9)	-0.0217073	0.102518	-0.2117	0.8327
alpha(10)	-0.0189856	0.103488	-0.1835	0.8548
alpha(11)	0.115203	0.102236	1.127	0.2625
alpha(12)	-0.0507697	0.136882	-0.3709	0.7115

Null hypothesis: no ARCH effect is present Test statistic: LM = 8.01666 with p-value = P (Chi-square (12) > 8.01666) = 0.783827

Since the P-value less than 0.05, the null hypothesis of no ARCH effects is rejected. This indicates the evidence of ARCH (q) effects. Above Table shows the results of ARCH LM test indicates that LM = 8.01666 there is an ARCH no effects in each of the 2 cases alpha(0), alpha(1). This results that the log-return price series are volatile and need to be modeled using ARCH or GARCH models.

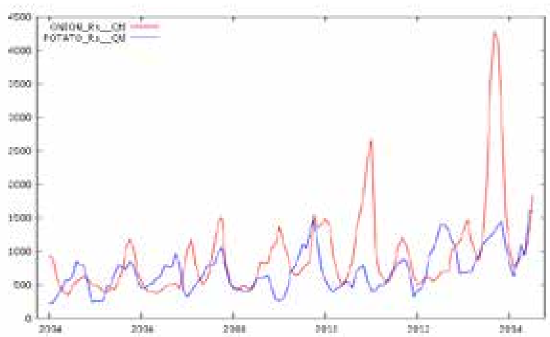

Figure: Onion and potato Price Volatility

Test for ARCH of order 12 (potato)
Table No.1.4

	Coefficient	Std. error	t-ratio	p-value
alpha(0)	13137.4	12459.6	1.054	0.2942
alpha(1)	-0.00671702	0.0978027	-0.06868	0.9454
alpha(2)	0.141772	0.205987	0.6883	0.4929
alpha(3)	0.315647	0.206563	1.528	0.1296
alpha(4)	-0.0733995	0.207542	-0.3537	0.7243
alpha(5)	0.0162860	0.205186	0.07937	0.9369
alpha(6)	0.137001	0.205226	0.6676	0.5059
alpha(7)	0.0885249	0.205503	0.4308	0.6675
alpha(8)	-0.0720217	0.206388	-0.3490	0.7278
alpha(9)	-0.171234	0.207423	-0.8255	0.4110
alpha(10)	-0.0958732	0.208438	-0.4600	0.6465
alpha(11)	-0.0781909	0.208898	-0.3743	0.7090
alpha(12)	0.208861	0.158499	1.318	0.1905

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Null hypothesis: no ARCH effect is present Test statistic: LM = 7.34657
With p-value = P Chi-square(12) > 7.34657) = 0.833887

The P-value less than 0.05, up to α3 level, it presence the null hypothesis of no ARCH effects is rejected. This indicates the evidence of ARCH (q) effects. Above Table no.1.4 shows the results of ARCH LM test indicates that LM = there is 7.34657 an ARCH no effects in each of the 4 cases alpha(0) to alpha(4) level. This results that the log-return price series are volatile and need to be modeled using ARCH or GARCH models.

Model 4: GARCH, using observations 2004:01-2014:07 (T = 127)
Dependent variable: ONION___Rs__Qtl
Standard errors based on Hessian

Table No.1.5

	Coefficient	Std. Error	z	p-value	
POTATO_Rs__Qtl	0.947242	0.0677265	13.9863	<0.00001	***
alpha(0)	62012.6	24225	2.5599	0.01047	**
alpha(1)	0.736296	0.326674	2.2539	0.02420	**
beta(1)	1.00002e-012	0.307861	0.0000	1.00000	

Mean dependent var	934.9843	S.D. dependent var	662.1230
Log-likelihood	-932.3927	Akaike criterion	1874.785
Schwarz criterion	1889.006	Hannan-Quinn	1880.563

Unconditional error variance = 235160

The variance equation the values of α_0, α_1, β_1 are statistically significant at 2% level of significance.

Model 5: GARCH, using observations 2004:01-2014:07 (T = 127)
Dependent variable: POTATO_Rs__Qtl
Standard errors based on Hessian

Table No.1.6

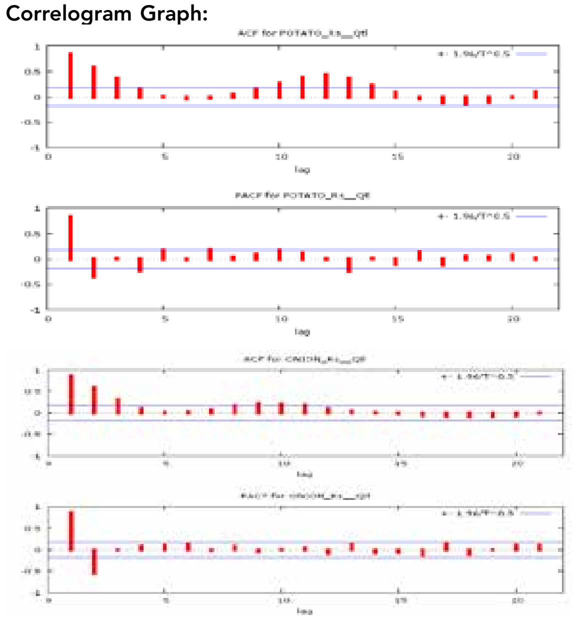
	Coefficient	Std. Error	z	p-value	
const	418.938	42.4782	9.8624	<0.00001	***
ONION___Rs__Qtl	0.249443	0.0365633	6.8222	<0.00001	***
alpha(0)	20455.5	6785.6	3.0146	0.00257	***
alpha(1)	0.770849	0.199001	3.8736	0.00011	***
beta(1)	1.00006e-012	0.128452	0.0000	1.00000	

Mean dependent var	707.5433	S.D. dependent var	314.8400
Log-likelihood	-871.3504	Akaike criterion	1754.701
Schwarz criterion	1771.766	Hannan-Quinn	1761.634

Unconditional error variance = 89266.8

The estimates of GARCH (1,1) model for potato that all the coefficients of mean and variance equation are statistically significant at both 1% and 3% level of significance. Estimates of onion shows that all the coefficients of mean and variance equation are statistically significant at 3% level.

Correlogram Graph:



Augmented Dickey-Fuller test: for ONION_Rs. Qtl
Including one lag of (1-L)ONION_Rs.Qtl (max was 12)
Sample size 125
Unit-root null hypothesis: a = 1
Test with constant
Model: (1-L)y = b0 + (a-1)*y(-1) + ... + e

1st-order autocorrelation coeff. for e	0.047
Estimated value of (a - 1)	-0.213735
Test statistic	tau_c(1) = -5.64654
Asymptotic p-value	8.09e-007

With constant and trend

Model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e

1st-order autocorrelation coeff. for e	0.009
Lagged differences	F(11, 101) = 7.436 [0.0000]
Estimated value of (a - 1)	-0.320907
Test statistic	tau_ct(1) = -5.64654
Asymptotic p-value	0.1416

For the present purposes the important coefficient is that of the lagged onion value. the t value of this Co efficient is significant at 0.1416 level. Look at the tau value of this Coefficient given in the above table it is significant at about the -5.64654 level, which is much higher than the critical 1%,5% and 10% critical tau values. In other words ,on the basis of the tau test, the coefficient of the lagged onion is not different from zero, thus suggesting that the onion time series is nonstationary.This reinforces the conclusion based on the sample graphic picture as well as the correlogram.

Augmented Dickey-Fuller test: for POTATO_Rs__Qtl
Including 12 lags of (1-L)POTATO_Rs__Qtl (max was 12)
Sample size 114
Unit-root null hypothesis: a = 1

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Test with constant

Model: (1-L)y = b0 + (a-1)*y(-1) + ... + e

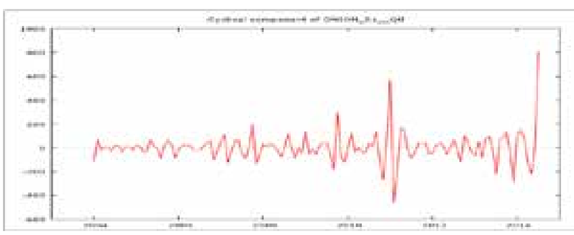
1st-order autocorrelation coeff. For e	0.030
Lagged differences	f(12, 100) = 5.963 [0.0000]
Estimated value of (a - 1)	-0.0900572
Test statistic	tau_c(1) = -1.25376
Asymptotic p-value	0.6531

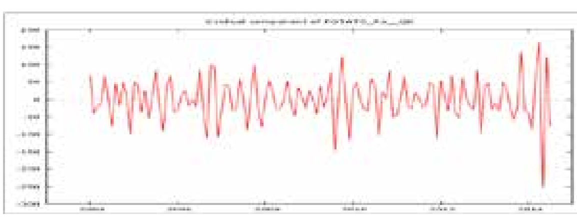
With constant and trend

Model: (1-l)y = b0 + b1*t + (a-1)*y(-1) + ... + e

1st-order autocorrelation coeff. For e	0.011
Lagged differences	f(12, 99) = 6.329 [0.0000]
Estimated value of (a - 1)	-0.263661
Test statistic	tau_ct(1) = -2.61424
Asymptotic p-value	0.2738

Out-put given in this table is divided in two part. All the estimated coefficients are individually highly statistically significant. on the basis of the t test Look at the tau value of this Coefficient given in the above table it is significant at about the-2.61424 level, which is much higher than the critical 1%,5% and 10% critical tau values. In other words, on the basis of the tau test, the coefficient of the lagged onion is not different from zero, thus suggesting that the onion time series is nonstationary.This reinforces the conclusion based on the sample graphic picture as well as the correlogram





Conclusions and Suggestions:

The Prices of Food Commodities in the Internal Markets have Shown Divergent Trends Reflecting the Supply-Demand Imbalances. GARCH (1, 1) models are the best volatility models for the prices of onion and potato stocks and flows. This inter-temporal statistic is a measure of instability over time and cannot fully convey

The degree of risk involved. Price volatility estimated as the predictable variance is found to have increased after 2007.

The agricultural output in the kharif season was also adversely affected by deficient rainfall in the first two months of the monsoon period of June–September. The high rate of overall inflation and particularly onion inflation witnessed during 2011 and 2013. The weather conditions for the rabi season have turned out to be favorable although post monsoon rainfall from October to December has been less than normal. The rainfall, however, is higher than last year.

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