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PRICE VOLATILITY AND INTEGRATION OF MAJOR DRY CHILLI MARKETS

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ABSTRACT

A research study was conducted in five major chilli markets of India viz., Guntur, Khammam, Byadagi, Nagpur and Virudhunagar. Time series data on monthly prices were collected from 2000-01 to 2012-13 in each market. The market prices of chilli were found to be highly volatile. Johansen's Multiple Co-integration procedure indicated presence of at least four integration equations at 5 per cent level of significance. Hence markets are having long run equilibrium relationship. Guntur, Nagpur and Virudhunagar markets came to short run equilibrium. Granger causality test showed a bidirectional influence between Khammam and Byadagi; Nagpur and Virudhunagar and unidirectional influence between Guntur and Byadagi; Guntur and Khammam.

KEYWORDS: Granger causality test, integration, Johansen's Multiple Co-integration, Volatile

INTRODUCTION

India from time immemorial is the "Home of Spices" producing almost all the spices of the world. Among the 16 important spices cultivated in India chilli, which comes under the category of pungent spices is most widely cultivated not only in India but also in the world. India is one of the leading producers of chillies in the world and is the only country rich in many varieties with different quality factors. Even though chilli occupies major position in Indian spices, there were very limited studies conducted in India on prices and market integrations. Keeping in view the importance of chillies in Indian trade there is a need to analyze the behaviour of prices of chillies. Hence the present study was undertaken with the objectives of assessing price volatility in major chilli markets and extent of integration among the major markets of chillies in India.

MATERIAL AND METHODS

For the present study, five major chilli markets in India *viz.,* Guntur and Khammam (A.P), Byadagi (Karnataka), Nagpur (Maharashtra) and Virudhunagar (Tamil Nadu) were selected. Time series data on monthly prices were collected from 2000-01 to 2012-13 in each market.

To assess the presence of volatility in chilli prices, ARCH-GARCH methodology was employed. Autoregressive Conditional Heteroscedasticity models are specially designed to model and forecast conditional variances. The variance of the dependent variable is modeled as a function of past values of the dependent variable and independent or exogenous variables. ARCH models were introduced by the Engle (1982) and generalized as GARCH (Generalized ARCH) by Bollerslev (1986).

GARCH Model

Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model was originally proposed by Bollerslev. The simplest GARCH model is the GARCH (1,1) model, which can be written as:

$$ó_t^2 = á_0 + á_1 u^2_{t-1} + á_2\, ó^2_{t-1}$$

which says that the conditional variance of '*u*' at time 't' depends not only on the squared error term in the previous time period but also on its conditional variance in the previous time period. This model can be generalized to a GARCH (*p*,*q*) model in which there are '*p*' lagged terms of the squared error term and '*q*' terms of the lagged conditional variances.

INTEGRATION TECHNIQUES

Augmented Dickey-Fuller test (ADF)

Before testing for integration among the selected markets, first, the price data series for all the markets selected were checked for its stationarity by employing Augmented Dickey-Fuller test (ADF). This test was conducted on the level and first differences of price series. The time series variables that are integrated, may be of

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same order, while the unit root test finds out which variables are integrated of order one, or I(1). The following ADF regression equation was tested for stationarity

$$\text{Ä}Y_t = \text{â}_t + \text{ä}Y_{t-1} + \text{á}_i + \sum_{i=1}^{n} \text{Ä}Y_{t-1} + e_t$$

where, $\text{Ä}Y_t = (Y_t - Y_{t-1})$; $\text{Ä}Y_{t-1} = (Y_{t-1} - Y_{t-2})$

Y_t = vector to be tested for co-integration; t = time or trend variable; e_t = pure white noise error term

The null hypothesis that ä = 0; signifying unit root, states that the time series is non-stationary, while the alternative hypothesis ä < 0, signifies that the time series is stationary, thereby rejecting the null hypothesis.

(i) Johansen's Multiple Co-integration test

To examine the price relation between two markets, the following basic relationship commonly used to test for the existence of market integration may be considered.

$$P_{it} = \text{á}_0 + \text{á}_1 P_{jt} + \text{å}_t$$

where,

P_i = Price series of chilli in ith market; P_j = Price series of chilli in jth market.

å_t = is the residual term assumed to be distributed identically and independently

á_0= represent domestic transportation costs, processing costs and sales taxes.

The test of market integration is straight forward if P_i and p_j are stationary variables.

Often, however, economic variables are non - stationary in which case the conventional tests are biased towards rejecting the null hypothesis.

For the present analysis, Johansen's vector error correction model (VECM) was also used to study the short run and long run association for equilibrium among markets and to know the speed of adjustments among the markets for long run equilibrium.

(ii) Granger Causality Test

The Granger test is based on a premise that if forecasts of some variable, say X, obtained by using both the past values of X and the past values of another variable Y, is better than the forecasts obtained using past values of X alone, Y is then said to cause X,

$$Y_i = a_i Y_{t-i} + b_i X_{t-i} + e_i \ldots\ldots\ldots\ldots\ldots (1)$$

$$X_i = c_i Y_{t-i} + d_i X_{t-i} + v_i \ldots\ldots\ldots\ldots\ldots (2)$$

where, X_i and Y_i are two stationary time series with zero mean: e_i and v_i are two correlated series. Since the series of the variable are usually non-stationary and integrated of order I(1), first difference of the variable is normally taken which is stationary. The optimal lag length of the variables is determined by minimizing Akaike's Information Criterion (AIC). Based on equations 1 and 2, unidirectional causation from one variable X to Y (i.e.

Table 1. Results of ARCH-GARCH analysis

Particulars	Guntur	Khammam	Byadagi	Nagpur	Virudhunagar
Alpha (α)	0.971419	0.93703	0.905577	0.968704	0.976871
Beta (β)	0.017555	0.269417	0.160154	0.401647	0.254125
α + β	0.988974	1.206447	1.065731	1.370351	1.230996

Table 2. Results of multiple co-integration analysis for chilli domestic markets

Hypothesized No. of CE(s)	Eigenvalue	Trace statistic	0.05 critical value	Prob.**
None *	0.2082	108.3931	88.80380	0.0010
At most 1 *	0.156333	72.91311	63.87610	0.0072
At most 2 *	0.129156	47.07357	42.91525	0.0182
At most 3 *	0.116263	26.05306	25.87211	0.0475
At most 4	0.046682	7.266573	12.51798	0.3175

Table 3. Results of vector error correction model for domestic chilli markets

Error Correction:	D(BYADAGI)	D(GUNTUR)	D(KHAMMAM)	D(NAGPUR)	D(VIRUDHUNAGAR)
CointEq1	-0.01273	0.106155	0.030336	0.065277	-0.0726
	(0.02862)	(0.03140)	(0.02922)	(0.02200)	(0.02803)
	[-0.44480]	**[3.38120]**	[1.03810]	**[2.96712]**	**[-2.59032]**
D(BYADAGI(-1))	0.078176	0.054654	0.060120	-0.0116	-0.06647
	(0.08890)	(0.09753)	(0.09078)	(0.06834)	(0.08706)
	[0.87942]	[0.56041]	[0.66230]	[-0.16977]	[-0.76340]
D(BYADAGI(-2))	0.174543	-0.09197	0.345373	0.061207	-0.08973
	(0.08867)	(0.09728)	(0.09054)	(0.06817)	(0.08684)
	[1.96847]	[-0.94539]	**[3.81444]**	[0.89792]	[-1.03320]
D(BYADAGI(-3))	-0.05224	-0.03749	0.137457	-0.0736	0.087688
	(0.09525)	(0.10449)	(0.09726)	(0.07322)	(0.09329)
	[-0.54841]	[-0.35881]	[1.41328]	[-1.00518]	[0.94000]
D(GUNTUR(-1))	0.059805	-0.07285	-0.03816	0.112388	0.112388
	(0.08111)	(0.08898)	(0.08282)	(0.06235)	(0.06235)
	[0.73733]	[-0.81867]	[-0.46074]	[1.80242]	[1.80242]
D(GUNTUR(-2)	0.041905	0.099019	0.101740	0.080943	-0.01135
	(0.08199)	(0.08995)	(0.08372)	(0.06303)	(0.08030)
	[0.51110]	[1.10084]	[1.21520]	[1.28419]	[-0.14128]
D(GUNTUR(-3))	0.149244	0.119276	0.107986	0.043452	-0.01234
	(0.07753)	(0.08506)	(0.07917)	(0.05960)	(0.07593)
	[1.92499]	[1.40231]	[1.36400]	[0.72904]	[-0.16251]
D(KHAMMAM(-1))	-0.07203	-0.09798	0.003754	0.154639	0.051153
	(0.08699)	(0.09543)	(0.08882)	(0.06687)	(0.08519)
	[-0.82806]	[-1.02673]	[0.04226]	**[2.31249]**	[0.60044]
D(KHAMMAM(-2))	-0.17149	0.026986	-0.185	-0.07544	0.082874
	(0.07978)	(0.08753)	(0.08147)	(0.06133)	(0.07814)
	[-2.14955]	[0.30832]	**[-2.27083]**	[-1.23004]	[1.06062]
D(KHAMMAM(-3))	-0.11807	-0.15817	-0.01989	-0.02202	0.071347
	(0.08317)	(0.09124)	(0.08492)	(0.06394)	(0.08145)
	[-1.41967]	[-1.73350]	[-0.23418]	[-0.34442]	[0.87593]
D(NAGPUR(-1))	0.162957	0.598358	0.166915	0.344976	0.147458
	(0.11974)	(0.13136)	(0.12227)	(0.09205)	(0.11727)
	[1.36097]	**[4.55507]**	[1.36516]	**[3.74775]**	[1.25742]
D(NAGPUR(-2))	0.132298	0.199916	0.340868	0.044271	-0.15403
	(0.12777)	(0.14018)	(0.13048)	(0.09823)	(0.12514)
	[1.03540]	[1.42615]	**[2.61249]**	[0.45069]	[-1.23087]
D(NAGPUR(-3))	0.082508	0.254362	-0.01912	-0.04892	0.019765
	(0.12896)	(0.14148)	(0.13169)	(0.09914)	(0.12631)
	[0.63979]	[1.79785]	[-0.14519]	[-0.49343]	[0.15649]
D(VIRUDHUNAGAR	-0.05252	0.052326	0.063966	0.036044	0.234112
(-1))	(0.09129)	(0.10016)	(0.09323)	(0.07018)	(0.08941)
	[-0.57529]	[0.52243]	[0.68614]	[0.51356]	[2.61827]
D(VIRUDHUNAGAR	0.098713	-0.09136	-0.03377	-0.02905	0.148595
(-2))	(0.09111)	(0.09995)	(0.09303)	(0.07004)	(0.08923)
	[1.08349]	[-0.91406]	[-0.36299]	[-0.41472]	[1.66529]
D(VIRUDHUNAGAR	-0.01434	-0.04904	0.019154	-0.05528	0.070485
(-3))	(0.09041)	(0.09919)	(0.09232)	(0.06951)	(0.08855)
	[-0.15856]	[-0.49440]	[0.20747]	[-0.79532]	[0.79599]
C	16.27637	16.41182	9.924598	7.649964	9.480301
	(26.0262)	(28.5530)	(26.5765)	(20.0080)	(25.4901)
	[0.62538]	[0.57478]	[0.37343]	[0.38234]	[0.37192]
R-squared	0.2033	0.2780	0.3184	0.2913	0.2418

Table 4. Results of pair-wise granger causality tests of chilli domestic markets

Null Hypothesis:	Obs	F-Statistic	Prob.
GUNTUR does not Granger Cause BYADAGI	153	5.04888	0.0023
BYADAGI does not Granger Cause GUNTUR		1.45878	0.2283
KHAMMAM does not Granger Cause BYADAGI	153	3.44335	0.0184
BYADAGI does not Granger Cause KHAMMAM		9.41364	1.E-05
NAGPUR does not Granger Cause BYADAGI	153	5.58154	0.0012
BYADAGI does not Granger Cause NAGPUR		1.04906	0.3728
VIRUDHUNAGAR does not Granger Cause BYADAGI	153	4.43250	0.0052
BYADAGI does not Granger Cause VIRUDHUNAGAR		0.10642	0.9562
KHAMMAM does not Granger Cause GUNTUR	153	2.75846	0.0445
GUNTUR does not Granger Cause KHAMMAM		6.33758	0.0005
NAGPUR does not Granger Cause GUNTUR	153	10.6878	2.E-06
GUNTUR does not Granger Cause NAGPUR		2.03058	0.1122
VIRUDHUNAGAR does not Granger Cause GUNTUR	153	5.12596	0.0021
GUNTUR does not Granger Cause VIRUDHUNAGAR		1.83828	0.1428
NAGPUR does not Granger Cause KHAMMAM	153	8.39713	3.E-05
KHAMMAM does not Granger Cause NAGPUR		3.90286	0.0102
VIRUDHUNAGAR does not Granger Cause KHAMMAM	153	4.46603	0.0049
KHAMMAM does not Granger Cause VIRUDHUNAGAR		2.81725	0.0412
VIRUDHUNAGAR does not Granger Cause NAGPUR	153	4.21451	0.0068
NAGPUR does not Granger Cause VIRUDHUNAGAR		4.34522	0.0058

X Granger causes Y) is observed if the estimated coefficient on the lagged X variable in equation (1) is statistically non-ero as a group and the set of lagged Y coefficient is zero in equation (2). Similarly, unidirectional causation from Y to X (i.e. Y Granger causes X) is implied if the estimated coefficient on the lagged Y in equation (2) are statistically different from zero as a group and the set of estimated coefficient on the lagged X variable in equation (1) is not statistically different from zero. Feedback or mutual causality (bi-directional) would occur when the set of coefficients on the lagged X variable in equation (1) and on lagged Y variable in equation (2) are statistically different from zero. Finally, independence exists when the coefficients of both X and Y variables are equal to zero.

RESULTS AND DISCUSSION

The results of ARCH-GARCH analysis are presented in Table 1. The sum of Alpha and Beta indicates ARCH and GARCH effect for the given markets. The value close to one indicates persistence of shocks or volatility in the market.

From the results it could be inferred that barring Guntur and Byadagi, the prices in the remaining markets were highly volatile during the period from 2000-01 to 2012-13. Compared to all other markets, prices in Nagpur market exhibited more volatility with a value equal to 1.37 as indicated by sum of Alpha and Beta. Khammam and Virudhunagar were more or less closer regarding volatility. These results are in line with that of Ajjan *et al* (2012). Only in Guntur market, the value was close to one (0.98) while in the remaining markets it was more than one.

Integration among Major Chilli Markets in India (2000-01 to 2012-13)

ADF test revealed that the price data series was non-stationary at level and became stationary after taking the first difference.

(i) Results of Co-integration Test

Johansen's Multiple Co-integration test conducted to study the long run integration among domestic markets indicated the presence of at least four co-integration equations at five per cent level of significance. Hence markets are having long run equilibrium. The results are presented in Table 2.

(ii) Results of Vector Error Correction Model (VECM)

From the results furnished in Table 3 it is clearly known that Guntur, Nagpur and Virudhunagar markets came to short run equilibrium as indicated by level of significance and the speed of adjustment was rapid. The prices of chilli in Khammam, Nagpur and Virudhunagar were influenced by their own monthly lags for long run equilibrium. Khammam market prices were influenced by two months lagged price of Byadagi market and Byadagi market prices were in turn influenced by Khammam market prices by two months lag. Also Khammam market influenced the prices of chilli in Nagpur market by one month lag and in turn prices in Khammam were influenced by two months lagged prices of Nagpur. One month lagged price of Nagpur influenced the prices in Guntur market. Thus it can be concluded that Khammam market prices were influenced by both Byadagi and Nagpur market prices.

(iii) Results of Granger Causality Test

From the results of Granger Causality test presented in Table 4 a bidirectional influence was observed between Khammam and Byadagi markets; Nagpur and Virudhunagar markets which implied that the chilli prices in Khammam were influenced by Byadagi and vice versa. Similarly Nagpur prices influenced Virudhunagar which in turn influenced Nagpur chilli prices. A unidirectional influence was observed between Guntur and Byadagi; Guntur and Kahammam i.e. chilli prices in Guntur market influenced prices in Byadagi and Khammam markets. Also Byadagi market prices were influenced by Nagpur and Virudhunagar. Both Guntur and Khammam chilli prices were influenced by Nagpur and Virudhunagar.

CONCLUSIONS

The study revealed that chilli prices in Khammam market of Andhra Pradesh was influenced by Byadagi market of Karnataka and vice-versa. The analysis further showed that Guntur and Khammam market chilli prices of Andhra Pradesh were influenced by Nagapur in Maharashtra and Virudhunagar in Tamil Nadu.

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