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Market Integration and Volatility in Edible Oil Sector in India

C. Sundaramoorthy, Girish K. Jha, Suresh Pal and V.C. Mathur
Indian Agricultural Research Institute, New Delhi

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SUMMARY

India is the largest producer as well as the consumer of vegetable oils in the world. The oilseed crops have registered significant growth in area and yield during the last decade but at the same time 50 per cent of the edible oil requirement is met through import, which accounts for around 60-70 per cent of the total agricultural imports of India. Recent bouts of extreme price volatility in global agricultural markets signify rising and more frequent threats to world food security. The present study examines the integration among different markets of major oilseeds both domestic as well as international markets. The Johansen co-integration test validates the existence of market integration in major oilseeds and edible oils within the domestic markets and between domestic and international markets as well. The volatility persisting in the oilseed markets was captured through the generalised autoregressive conditional heteroscedasticity (GARCH) model. The linkage between the different markets seems to transmit volatility from one market to another. Understanding the price dynamics is essential for effective policy that will ensure the welfare of the consumers as well as the producer farmers.

Keywords: Edible oil, GARCH, Johansen Co-integration, Market integration, Price transmission.

1. INTRODUCTION

Fluctuations in commodity prices have always been a major concern of the producers as well as the consumers as they affect their decision and planning process. Agricultural commodity prices are volatile in nature and the volatility itself changes over time depending on the demand and supply of the commodity. Changes in volatility can affect market variables by directly affecting the marginal value of storage and by affecting a component of the total marginal cost of production, the opportunity cost of producing the commodity now rather than waiting for more price information (Pindyck 2004). Oilseeds and edible oils are two of the most sensitive agricultural commodities. India is one of the largest producers of oilseeds in the world and this sector occupies an important position in the agricultural economy and accounted for an estimated production of over 31 million tonnes of nine major cultivated oilseeds during the year 2010-11. The diverse agro-climatic conditions of India enable it to grow a wide range of oilseed crops. Groundnut, soybean and rapeseed & mustard are the three major oilseeds that account for over 80 per cent of total oilseeds output and around 60 per cent of edible oils consumption in the country.

The oilseed crops have registered significant growth in area and yield during the last decade. Despite this promising growth, the imports of edible oils too were very high, hovering between 60-70 per cent of the total agricultural imports of India. The two major interventions, which have very significantly contributed to the development of the oilseed sector in the country, are Technology Mission on Oilseeds (TMO) and liberalisation of trade in oilseeds in the post-WTO period. In 1986, the Government of India (GOI) established the TMO in order to enhance the production

Corresponding author: Girish K. Jha
E-mail address: girish.stat@gmail.com

of oilseeds in the country. The TMO launched special initiatives on several critical fronts such as improvement of oilseed production and processing technology, additional support to oilseed farmers and processors and enhanced customs duty on the import of edible oils. Consequently, there was a significant increase in oilseeds area, production and yields, which continued till the late 1990s. This is clearly evident from an impressive increase in the production of oilseeds from about 11.3 million tonnes in 1986-87 to 24.98 million tonnes during 1998-99. There was almost a 2 per cent growth in yield over these years and most of the growth came from soybean, rapeseed & mustard and groundnut (Chand *et al*. 2004).

However, India's commitment to fulfil the obligations towards various international trade agreements and also to meet the increasing demand-supply deficits, import restrictions on edible oils were reduced in the late 1990s, and these were gradually brought under Open General License. This led to a significant slump in the domestic oilseeds market, as edible oil prices fell sharply in line with the low international prices prevailing at that time. Subsequently, the duty structure was modified so as to maintain a duty differential between crude and refined edible oil in order to protect the domestic industry. Nevertheless, due to high import dependence, domestic edible oil prices remain highly correlated to the movements in the international prices, and this has resulted in volatility in the domestic prices.

A crucial measure of marketing performance is the effectiveness with which markets move goods across space and time at the lowest possible costs. Market integration indicators are typically used to measure the performance of markets. The earlier studies on the integration for oilseed, oil and meal markets concentrated on the pairs of individual markets and used correlation coefficient and Johansen co-integration method. The correlation coefficient between the monthly prices was used to measure the short run market integration. Since the correlation is not a statistically robust measure, Ravallion market integration test was used for short run market integration (World Bank 1997). The long run market integration was studied using the Johansen vector error correction model. The World Bank (1997) study was done in the immediate aftermath of bringing the oilseed and edible oil trade under liberalisation, so it could not capture the price movements in the domestic markets in the wake of liberalisation and also the level of integration between the domestic and international market in the free market regime.

Commodity price volatility is not a new problem in India, but has grown in the wake of recent liberalization and globalization process (Pahariya and Mukherjee 2007). Moreover India's move towards a liberalized external trade created a link between the domestic economy and the global market. The more open trade regime enabled India to capture emerging opportunities in the world market but at the same time, it exposed the domestic economy to the risks of fluctuating world prices. The present paper attempts to understand the co-movement of the prices among different domestic markets for major oilseed crops and oils, their linkages with international prices. It also estimates the volatility exhibited by the domestic prices in various markets and provides suitable policy suggestions for the pricing policy for the sustainability of the oilseed sector.

2. METHODOLOGY

2.1 Data Description

The data set consists of monthly prices from the major markets of oilseeds and edible oils in India. The major markets for edible oilseeds considered includes Rajkot and Hyderabad markets for groundnut, Delhi and Hingna markets for mustard, Sangli market for soybean oil, Jaipur and Chennai markets for groundnut oil, Kanpur and Patna markets for mustard oil. The international prices considered for the analysis were cost, insurance and freight (c.i.f.) Argentina for groundnut, c.i.f. Rotterdam for groundnut oil, free on board (f.o.b) Rotterdam for mustard oil and Chicago oil futures for soybean. The prices chosen for the groundnut, groundnut oil and mustard oil are the international reference price for the respective commodities. In case of soybean oil, which is widely used as cooking oil in USA, the soybean oil futures traded in Chicago Board of Trade was chosen as the international reference price. The price series span from January 2001 to December 2010 for all series except groundnut which includes data series from January 1996 to December 2010 as the monthly price data for the commodity was available since 1996.

Table 1. Descriptive statistics of the price series of oilseeds and edible oils

Commodity	Market	Mean	Maximum	Minimum	Standard deviation	Skewness	Kurtosis
Groundnut	c.i.f Argentina	4014.33	7165	2694	1091.7	1.28	3.89
	Hyderabad	2432.82	4313	1250	722.9	0.53	2.29
	Rajkot	1785.61	3110	950	546.4	0.68	2.13
Groundnut oil	c.i.f. Rotterdam	5359.70	10864	3085	1745.4	1.15	4.56
	Chennai	5529.09	8604	2787	1198.0	0.10	2.97
	Jaipur	6012.32	9671	3566	1419.0	0.38	2.37
Mustard	Delhi	2121.75	3175	1240	583.5	0.45	2.03
	Hingna	1783.00	2884	1101	429.0	0.43	2.36
Mustard oil	f.o.b. Rotterdam	3630.64	7438	1542	1253.6	0.75	3.45
	Kanpur	4768.52	7103	2800	1013.0	0.15	2.71
	Patna	5160.18	6903	2650	989.4	–1.08	3.74
Soybean oil	Chicago Oil Future	2948.80	6056	1495	1078.9	0.84	3.03
	Sangli	1525.50	2775	930	412.6	0.81	2.90

Data Source: Agricultural prices in India for domestic prices and World Bank for international prices.

The descriptive of the price series is given in Table 1. The instability in the prices of both domestic and international markets was measured through Cuddy Della Valle index. The international reference price for mustard oilseed was not available and hence not used for computation of instability. In order to establish the co-movement of the commodity prices among different domestic markets as well the domestic and international markets, Johansen co-integration approach was used. The GARCH model was employed to trace out the volatility that was prevalent in the prices of the edible oilseeds.

2.2 Cuddy Della Valle Index

Cuddy Della Valle Instability index (Cuddy and Della Valle 1978) is a modification of coefficient of variation to accommodate trend present in the data, which is commonly present in economic time series data. This method is superior over other scale dependent measures such as standard deviation or root mean square of the residuals obtained from the fitted trend lines of the raw data, and hence suitable for cross comparisons. The Cuddy Della Valle Index (CDVI) was calculated as follows

$$CDVI = CV\sqrt{1-\bar{R}^2} \qquad (2.1)$$

where, CV is coefficient of variation, and $\bar{R}^2$ is adjusted coefficient of determination.

2.3 Co-integration Analysis

The estimation of price interdependence using time series data is subject to several considerations. The price relationship between different markets were examined by earlier studies using correlation coefficients (Lele 1967, Stigler and Sherwin 1985) or regression of the type given below (Mundlak and Larson 1992, Gardner and Brooks 1994)

$$p_{1t} = \mu + \beta_1 p_{2t} + \in_t \qquad (2.2)$$

where p_{1t} and p_{2t} denotes the prices from two spatially separated markets of the commodity under consideration, μ and β_1 are parameters to be estimated while $\in_t$ denotes an independent and identically distributed error term with zero mean and constant variance.

In the above analysis, presence of non-stationarity and differences in quality and high transfer cost may invalidate standard econometric test and thus give misleading results regarding the degree to which the price signals are being transmitted between markets. The null hypothesis that the prices of two markets are related would be rejected without necessarily ruling out a high degree of price linkage. It becomes necessary to employ a more general model that takes into account the stationary property and also allow for some flexibility in specification. The validity of the model with respect to the non-stationary problem can be checked by examining the order of integration of the error term in the above equation. Engle and Granger (1987) have shown that even if variables are non-stationary, a linear combination of them might be stationary. The linear combination is termed as the co-integrating equation and may be interpreted as a long run equilibrium relationship among them. The presence/absence of co-integration determines the specification of the model to be used for causality testing. If the series are co-integrated, the causality testing should be based on vector error correction model (Johansen 1988, Johansen and Juselius 1992). The concept of co-integration and error correction will enable us to study the long run relationship between the price series and the deviations of the price series from their respective long-run trends.

Johansen maximum likelihood method

Johansen's methodology takes its starting point as the vector auto regression (VAR) of order *p.* In case the prices from two spatially separated markets are cointegrated, the error correction model (ECM) form of the VAR system is as follows

$$\Delta p_t = \mu + \sum_{i=1}^{p-1} \Gamma_i \Delta p_{t-i} + \prod p_{t-p} + \in_t \qquad (2.3)$$

where μ is a constant term and $\in_t$ are identically and independently distributed residuals with zero mean and contemporaneous covariance matrix Ω, while the operator Δ denotes that the prices have been differenced in order to achieve stationarity. $\prod p_{t-p}$ is the long run relationship while the matrix $\prod$ can be further decomposed such that $\prod = \alpha\beta'$ where both α and β are $n \times r$ matrices, r represents the number of independent co-integration relations with $0 < r < n$. β is the co-integrating vectors and α is the short run adjustment coefficients. The advantage of Johansen method is that it does not impose the number of co-integration relationship beforehand, testing and estimation of the number of co-integration relationships are carried out simultaneously. The inclusion of the levels of the prices alongside their differenced terms is central to the concept of the error correction model. The model also allows testing for causality in the Granger sense, providing evidence on which direction price transmission is occurring.

2.4 GARCH Model

An autoregressive integrated moving average (ARIMA) model is characterized by the notation ARIMA (p, d, q) where p, d and q denote orders of auto-regression, integration (differencing) and moving average respectively. ARIMA is a parsimonious approach which can represent both stationary and non-stationary processes. An ARMA (p, q) process is defined by the equation

$$p_t = \mu + \phi_1 p_{t-1} + \phi_2 p_{t-2} + \ldots + \phi_p p_{t-p} + \in_t - \theta_1 \in_{t-1} - \theta_2 \in_{t-2} - \ldots - \theta_q \in_{t-q} \qquad (2.4)$$

where p_t is the price at time period t, μ is a constant term, ϕ_i ($i = 1, 2, \ldots, p$) and θ_j ($j = 1, 2, \ldots, q$) are model parameters. $\in_t$ is a random error at time period t and are assumed to be independently and identically distributed with a mean of zero and a constant variance of σ^2. However, in many practical applications, residuals obtained after fitting of appropriate ARIMA model may have non-constant error variance. Engle (1982) proposed to model time-varying conditional variance with auto-regressive conditional heteroscedasticity (ARCH) processes using lagged disturbance. In order to capture the dynamic behaviour of conditional variance, ARCH model with higher order is required. Generalised ARCH (GARCH) model was postulated by Bollerslev (1986) based on infinite ARCH specification thereby reducing the number of estimated parameters to two. The GARCH model incorporates conditional variance terms as additional explanatory variables. This allows the conditional variance to follow an ARMA process. If we write the residual as

$$\in_t = v_t \sigma_t = v_t \sqrt{h_t} \qquad (2.5)$$

where σ_t^2 is written as h_t and v_t has zero mean and unit variance, we can then write the conditional variance as

$$h_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i u_{t-1}^2 + \sum_{j=1}^{q} \beta_j h_{t-j} \qquad (2.6)$$

with $\alpha_0 > 0$, $\alpha_i \geq 0$ for all $i = 1, \ldots, p$ and $\beta_j \geq 0$ for all $j = 1, \ldots, q$. The sum $\alpha_i + \beta_j$ gives the degree of persistence of volatility in the series. The closer the sum to one, greater is the tendency of volatility to persist for longer time. If the sum exceeds one, it is indicative of an explosive series with a tendency to meander away from mean value. The forecasting performance of fitted models is assessed with respect to two traditional accuracy measures, viz., the mean absolute error (MAE) and the mean absolute percentage error (MAPE).

$$\text{Mean absolute error} = \sum_{t=1}^{n} | p_t - \hat{p}_t | / n \qquad (2.7)$$

Mean absolute perpcentage error

$$= 100 \sum_{t=1}^{n} \left| \frac{p_t - \hat{p}_t}{p_t} \right| / n \qquad (2.8)$$

3. RESULTS AND DISCUSSION

The first step in time series analysis is to plot the data. Fig. 1 shows some of the time series graphs of the price movement in different markets, which reveal a positive trend over time. Similar trend was observed in case of other price series. The instability of the price series over the trend were worked out using Cuddy Della Valle index (CDVI). The instability of the international prices is quite high as compared to the domestic prices. Among the domestic prices the instability is comparatively higher in the markets for soybean oil followed by mustard price in Delhi market, groundnut oilseed price in Hyderabad and Rajkot markets respectively (Table 2).

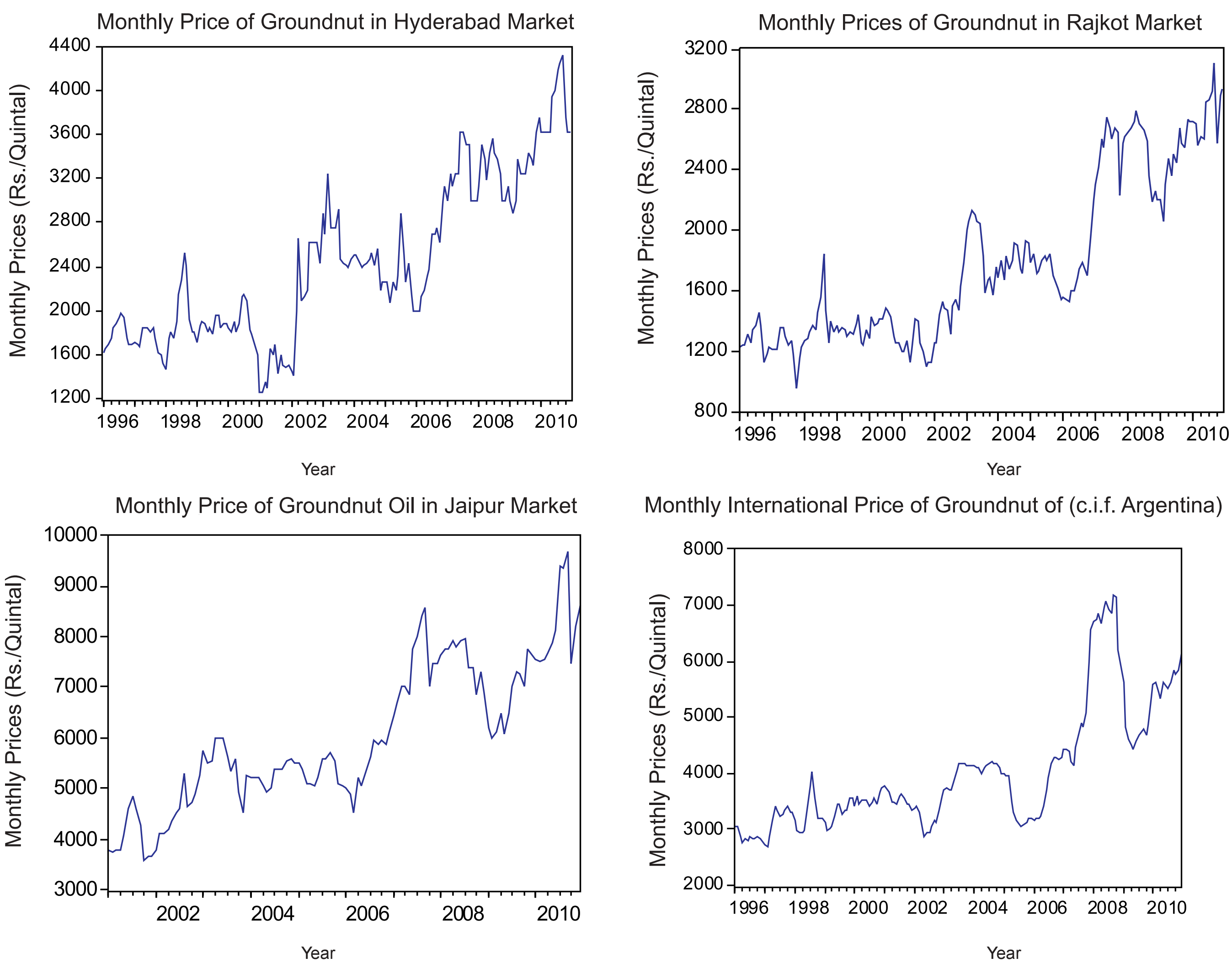

Fig. 1. Monthly price series of selected oilseeds and edible oils in domestic and international markets.

Table 2. Instability of the domestic and international prices of oilseed and edible oils

Commodity	Domestic Market Prices	CDVI	International Prices	CDVI
Groundnut	Rajkot	14.83	c.i.f. Argentina	22.11
	Hyderabad	15.58		
Mustard	Delhi	17.64	-	-
	Hingna	13.58		
Groundnut oil	Chennai	11.19	c.i.f. Rotterdam	26.44
	Hyderabad	15.58		
Mustard oil	Kanpur	13.07	f.o.b. Rotterdam	24.35
	Patna	12.92		
Soybean oil	Sangli	18.30	Chicago Oil Futures	27.50

3.1 Domestic Market Integration

Market integration analysis involves the study of the price relationship between homogeneous commodities sold in geographically separated markets. For the integration analysis, oilseed and edible oil price series were pre-tested to check for the stationarity of the series using Augmented Dickey-Fuller (ADF) test and Phillips Peron (PP) test. The results of the stationarity test on level and first differenced price series (Table 3) showed that both the test failed to reject the null hypothesis of presence of unit root in the time series data at level, revealing that the price series are non-stationary. Non-stationarity implies that shocks to the series are permanent, rendering the mean dependent on time. Both ADF and PP test reject the null hypothesis of the unit root for the oilseed and edible oil price series at first difference. The results suggest that the prices of oilseeds and edible oils are integrated of order one, *i.e.*, stationary in first difference.

Table 3. Unit root test for the oilseed and edible oil price in different markets in India

Prices	ADF test		PP test	
	Level	Ist difference	Level	Ist difference
Groundnut, Hyderabad	–1.78	–14.15**	–1.45	–15.00**
Groundnut, Rajkot	–1.29	–14.59**	–0.84	–15.29**
Groundnut oil, Chennai	–2.32	–12.67**	–1.31	–13.18**
Groundnut oil, Jaipur	–1.62	–12.21**	–1.20	–12.87**
Mustard oil, Kanpur	–2.10	–11.61**	–1.82	–12.01**
Mustard oil, Patna	–2.57	–9.80**	–2.21	–9.63**
Mustard oilseed, Delhi	–1.33	–12.39**	–1.18	–12.28**
Mustard oilseed, Hingna	–2.01	–13.67**	–1.52	–17.80**
Soybean oil, Sangli	–2.13	–9.77**	–2.14	–10.45**

Note: **significant at 1% level;
Critical values: –3.49 (1%), –2.89 (5%), –2.58 (10%).

Determination of the lag length is the next important step before proceeding for the co-integration analysis. The lag length of the series was obtained by estimating the vector auto-regression using the undifferenced data and the lag length was determined based on the Schwarz information criterion (SIC). The SIC criteria suggested an optimal lag length of one for all the time series (a maximum of 4 lags was considered). The co-integration was examined for price series of major oilseed crops and the edible oils in major markets of the country. The trace test and the max-eigen value statistics obtained from the Johansen co-integration rank test are presented in Table 4. The results suggest that there is at least one co-integrating relationship between the major markets for groundnut and its oil, and mustard oilseed, while there is no co-integrating relationship in the case of mustard oil markets.

Table 4. Johansen co-integration test results for major oilseeds and edible oil prices

Price series	Maximum eigen value test		Trace test	
	H_0:r = 0	H_0:r = 1	H_0:r = 0	H_0:r = 1
Groundnut oilseed (Rajkot –Hyderabad)	28.24*	1.35	29.59*	1.35
Groundnut edible oil (Chennai – Jaipur)	23.47*	3.28	26.75*	3.28
Mustard oilseed (Delhi –Hingna)	20.16*	2.40	22.57*	2.41
Mustard edible oil (Kanpur-Patna)	8.29	6.17	14.47	6.17

Note: Johansen (1988) Max-eigen and Trace Statistics. r = 0: no co-integrating relationship; r = 1: at most one co-integrating relationship. Critical values at 5% level of significance are 14.26 (r = 0) and 2.71 (r = 1) for Max-eigen test and 15.49 (r = 0) and 3.84 (r = 1) for Trace test.

There exists a direct positive relationship between the prices of oilseed and edible oils in different markets. In case of the groundnut oilseed market (Rajkot and Hyderabad), the co-integrating vector shows that one per cent rise in the prices at the Rajkot market results in 0.97 per cent increase in the prices in the Hyderabad market. The Granger causality test reveals that the Rajkot market statistically causes the changes in the Hyderabad market. The groundnut edible oil markets at Chennai and Rajasthan are co-integrated and the Granger causality is bi-directional. The markets for mustard oil are not integrated, whereas the mustard oilseed market of Delhi and Hingna are integrated with Delhi market, a major consumption centre, leading the prices. There is no co-integration between the mustard edible oil markets in Kanpur and Patna revealing the absence of any long run equilibrium relationship between these two markets.

The short run price dynamics of the oilseed as well as the edible oil was ascertained by error correction models for those markets which are co-integrated (Table 5). The adjustment coefficient for the groundnut oilseed markets at Hyderabad is significant and it adjusts itself by 25 per cent per month in order to maintain the long run equilibrium with the prices in the Rajkot market. In case of the groundnut edible oil market, there is a bi-directional causality relationship and hence, the adjustment coefficient is significant for both markets. The Chennai market corrects itself by 21 per cent, while the Jaipur market adjusts by 16 per cent per month in the short run to maintain the long run equilibrium.

Table 5. Long-run and short-run coefficients of the error correction model

Model	Long-run coefficients (β)		Short-run coefficients (α)		Co-integration rank
			α_1	α_2	
Groundnut oilseed (Hyderabad –Rajkot)	1	–0.97 (0.05)	**–0.26**** (0.07)	0.11 (0.06)	1
Groundnut edible oil (Chennai – Jaipur)	1	–0.88 (0.06)	**–0.22**** (0.08)	**0.16*** (0.07)	1
Mustard oilseed (Delhi –Hingna)	1	–1.18 (0.07)	–0.08 (0.05)	**0.31**** (0.09)	1

*significant at 5% level of significance;**significant at 1% level of significance; (standard error in the parentheses)

In case of mustard oilseed, Hingna market corrects itself by 30 per cent per month in the short run to maintain the equilibrium price relationship in the long run. Having understood the adjustment of prices of various markets with respect to their lead market, it becomes necessary to track the relationship between the domestic and the international market.

3.2 Domestic and International Market Integration

The international prices were found to be integrated of order one using the Augmented Dickey Fuller (ADF) and Phillips Perron (PP) tests (Table 6).

Table 6. Unit root test for the edible oil price in international market

Prices	ADF test		PP test	
	Level	Ist difference	Level	Ist difference
Groundnut oilseed c.i.f. Argentina	–1.51	–8.27**	–1.16	–7.99**
Groundnut oil c.i.f. Rotterdam	–1.73	–6.71**	–1.70	–6.83**
Mustard oil f.o.b. Rotterdam	–1.48	–5.56**	–1.60	–9.45**
Soybean oil Chicago oil Futures	–0.93	–7.26**	–0.98	–7.35**

Note: **significant at 1% level;
Critical values: –3.49 (1%), –2.89 (5%), –2.58 (10%).

Table 7. Johansen co-integration test results for domestic and international prices

Price series	Maximum eigen value test		Trace test	
	H_0:r = 0	H_0:r = 1	H_0:r = 0	H_0:r = 1
Groundnut oilseed$	27.59**	17.67*	46.13**	18.54*
Groundnut edible oil$	48.99**	25.40**	23.58**	20.61**
Mustard oil$	13.79	7.43	25.22	11.42
Soybean edible oil	18.56**	1.12	19.68**	1.12

Note: Critical values at 5% level of significance are 21.13 (r = 0), 14.26 (r = 1) and 3.84 (r = 2) for Max-eigen test and 29.79 (r = 0), 15.49 (r = 1) and 3.84 (r = 2) for Trace test ($ linkage between three markets was studied)

The co-integration between the domestic and the selected reference international market prices were tested using the Johansen co-integration test. The trace test and max-eigen value test (Table 7) reveal the presence of the co-integration between the domestic and international markets for groundnut oilseed market and the soybean oilseed market. There is absence of any co-integration between the markets for groundnut and mustard oil.

The Granger causality test for the groundnut market shows that the domestic market is influencing the prices of the international market, whereas in the case of soybean oil market the international price leads the domestic prices. In case of soybean oil market, the domestic market adjusts much faster at the rate of around 30 per cent per month to maintain the equilibrium between domestic and international market.

3.3 Volatility of Oilseeds and Edible Oil Prices

In order to capture the volatility persisting in the oilseed and edible oil price series, we first modelled the price series with best fitting ARIMA model. The first step in the process of ARIMA modelling is to check for the stationarity of the series as the estimation procedure are available only for stationary series. Stochastic trend of the series was removed by differencing while logarithmic transformation was employed to stabilize the variance. After the appropriate transformation and differencing, multiple ARMA models were chosen on the basis of autocorrelation function (ACF) and partial autocorrelation function (PACF) that closely fit the data. Then the parameters of the tentative models were estimated through any nonlinear optimization procedure such that an overall measure of errors is minimized or the likelihood function is maximized. Lastly, diagnostic checking for model adequacy was performed for all estimated models through plot of residual ACF and via Portmanteau test like Box-Pierce and Ljung-Box tests. In this study Ljung- Box test has been used. The most suitable ARIMA model was selected using the smallest AIC or SIC value and the lowest root mean square error (RMSE).

Table 8 shows the coefficients of the ARIMA model fitted to the different price series. After fitting the ARIMA structure for the price series, we determined the residuals and then squared them, which was subjected to the ARCH-LM test to check for the presence of any auto-regressive conditional heteroscedasticity. The results (Table 8) show that the groundnut seed price at Hyderabad and Rajkot markets and the mustard oil price at Kanpur along with the soybean oil price at Sangli market exhibit heteroscedasticity, which can be modelled through GARCH model.

Table 8. ARIMA model for oilseed and edible oil price series

Commodity	Variables	Coefficients	ARCH-LM (Prob. F)
Groundnut,	C	0.0044**	**0.0003**
Hyderabad	AR(1)	0.883**	
	MA(1)	–0.999**	
Groundnut,	C	0.005**	**0.0003**
Rajkot	AR(1)	0.862**	
	MA(1)	–0.993**	
Groundnut oil,	C	0.004**	0.2581
Chennai	AR(1)	0.812**	
	MA(1)	–0.985**	
Groundnut oil,	C	0.005**	0.5193
Jaipur	AR(1)	0.823**	
	MA(1)	–0.985**	
Mustard oil,	C	0.003*	**0.0001**
Kanpur	AR(1)	0.933**	
	MA(1)	–0.986**	
Mustard oil,	C	0.006	0.7474
Patna	AR(1)	0.064*	
	MA(1)	-	
Mustard,	C	0.004	0.7263
Delhi	AR(1)	–0.481	
	MA(1)	0.577*	
Mustard,	C	0.006*	0.2876
Hingna	AR(1)	0.496**	
	MA(1)	–0.758*	
Soybean oil,	C	6.11*	**0.0490**
Sangli	AR(1)	0.888**	
	MA(1)	–0.997**	

Note: **significant at 1% level; * significant at 5% level

Again, the most suitable GARCH model was selected using the smallest AIC and SIC values. GARCH(1, 1) was selected as the most appropriate model for all the price series and the summary of the fitted model is presented in Table 9. The forecasting performance of fitted GARCH model for different price series were evaluated in terms of mean absolute error (MAE) and mean absolute percentage error (MAPE). The graph of fitted GARCH (1,1) model along with data points for groundnut prices for Hyderabad market is exhibited in Fig. 2 for illustration. The result reveals that the groundnut prices at Hyderabad exhibit a high and persisting volatility as reflected by the sum of α and β co-efficients. The volatility in the groundnut prices at Rajkot and mustard oil prices at Kanpur are relatively less volatile as the sum of α and β co-efficient are 0.20 and 0.41, respectively. Another significant thing that emerges is that the volatility in the soybean oil is very high and persistent ($\alpha + \beta = 1$).

Table 9. Summary of GARCH model for various price series

Commodity	Variables	Coefficients	ARCH-LM (Prob. F)	MAE	MAPE
Groundnut, Hyderabad	C	0.0003	0.647	131.73	5.55
	RESID(−1)^2 (α)	0.070*			
	GARCH(−1) (β)	0.871**			
Groundnut, Rajkot	C	0.0037*	0.841	91.37	5.29
	RESID(−1)^2 (α)	0.235*			
	GARCH(−1) (β)	−0.037			
Mustard oil, Kanpur	C	0.001**	0.698	156.44	3.21
	RESID(−1)^2 (α)	0.417**			
	GARCH(−1) (β)	0.0037			
Soybean oil, Sangli	C	0.1017	0.650	107.49	6.71
	RESID(−1)^2 (α)	0.33*			
	GARCH(−1) (β)	0.67**			

Note: **significant at 1% level; * significant at 5% level

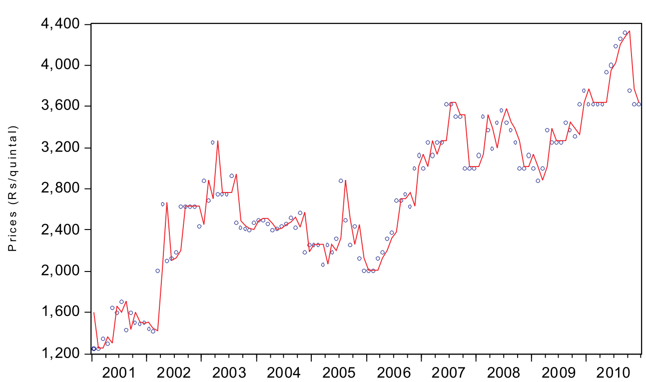

Fig. 2. Fitted GARCH (1,1) model along with data points for groundnut prices in Hyderabad market.

The volatility in the groundnut seed market at Hyderabad may be high due to the short run price dynamics. Hyderabad market adjusts itself in the short run by 25 per cent per month, while the adjustment at the Rajkot market is insignificant. This may be the reason for the higher volatility prevalent in the Hyderabad market ($\alpha + \beta = 0.94$) and comparatively lesser volatility in the prices of Rajkot market. This may be attributed to the fact that Rajkot market is the production centre whereas the Hyderabad market is consumption centre for groundnut. The higher volatility in the consumption centre may be due to the competition from the imported edible oils that exhibit higher degree of volatility. The volatility in the soybean oil market may be due to higher instability prevalent in the international market for the soybean oil and there exists a strong linkage between the domestic and international market with the international prices as the market leader. Soybean oil is one of the largest import items among the edible oils and it's imminent that the volatility prevalent in the international market will have its influence on the prices prevailing in the domestic markets for soybean oil. The volatility pattern observed in the prices of the groundnut in Hyderabad market and that of soybean oil in Sangli market are showing volatility clustering, reflected by periods of high prices followed by high prices and periods of low prices being followed by low prices.

4. CONCLUSIONS

India is the largest producer of oilseeds in the world and the oilseeds sector occupies an important position in the country's economy. The growth in the domestic production of oilseeds has not been able to keep pace with the growth in the demand in the country. Low and unstable yield of most oilseed crops and uncertainty in returns to investment, which result from the continuing cultivation of oilseeds in rainfed, high risk production environments, are the factors leading to this situation of wide demand-supply gap. As a result, the reliance on the imports has become inevitable which has its impact on the prices and production in the domestic oilseed sector. The long-term equilibrium relationship between the different markets of the edible oils as well the oilseeds provide a clear evidence of the integration of major domestic markets of the edible oils. This implies that prices in domestic markets move together in response to changes in the demand and supply and other economic variables. The volatility in the prices was captured using the GARCH model which reveals that persistent volatility is prevalent in the markets of Hyderabad (groundnut), which is a consumption centre, while the volatility is less pronounced in the centres like Rajkot (groundnut) and Kanpur (mustard oil) which are major production centres. Moreover there is also evidence of linkage between the domestic and international markets for edible oilseeds and it also serves as transmission belt to transmit instability from one domestic market to the other as evident from the persistence of volatility in soybean oil prices at Sangli market. The main problem of increased volatility is the associated uncertainty of production. Increased volatility can be addressed through stock management and by employing risk management instruments like crop insurance, futures markets, etc. It becomes pertinent for the policy makers to understand the proper linkage prevailing among various markets and implement appropriate strategies so that the welfare of the consumers as well as the producer farmers are ensured. A systematic approach for providing adequate market support for oilseed producers will go a long way in ensuring higher production of oilseed crops.

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REFERENCES

Bollerslev, Tim (1986). Generalized autoregressive conditional heteroscedasticity. *J. Econ.*, **31(3)**, 307-327.

Chand, R., Jha, D. and Mittal, S. (2004). WTO and oilseeds sector: challenges of trade liberalization. *Econ. Polit. Weekly*, February **7**, 533-537.

Cuddy, J.D.A and Della Valle, P.A. (1978). Measuring the instability in time series data. *Oxford B. Econ. Stat.,* **40(1)**, 79-85.

Engle, R.F. and Granger, C.W. (1987). Co-integration and error correction: representation, estimation and testing. *Econometrica*, **55**, 251-276.

Engle, R.F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of U.K. inflation. *Econometrica*, **50(4)**, 987-1008.

Franses, P.H., Kofman, P. and Moser, J. (1994). GARCH effects on a test of cointegration. *Rev. Quantitative Finance Accounting*, **4**, 19-26.

Gardner, B. and Brooks, K.M. (1994). Food prices and market integration in Russia: 1992-1993. *Am. J. Agr. Econ.*, **76**, 641-646.

Johansen, S. (1988). Statistical analysis of cointegration vectors. *J. Econ. Dyn. Control*, **12**, 231-254.

Johansen, S. and Juselius, K. (1992). Testing structural hypotheses in a multivariate cointegration analysis of the PPP and the UIP for UK. *J. Econometrics*, **53**, 211-244.

Lele, U. (1967). Market integration: a study of sorghum prices in western India. *J. Farm Econ.*, **49**, 149-159.

Mundlak, Y. and Larson, D.F. (1992). On the transmission of world agricultural prices. *World Bank Econ. Rev.*, **6**, 399-422.

Pahariya, N.C and Mukherjee, C. (2007). Commodity revenue management: India's rapeseed/mustard oilseed. Working paper. International Institute for Sustainable Development.

Pindyck, R.S. (2004). Volatility and commodity price dynamics. *J. Futures Markets.* **24,** 1029-1047.

Stigler, G. and Sherwin, R.A. (1985). The extent of the market. *J. Law Econ.*, **28**, 555-585.

World Bank (1997). The Indian oilseed complex: capturing market opportunities, Report No. 15677-IN, World Bank, Washington D.C.