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Research Paper

Is a World Price Influencing Indian Vegetable Oil Market? Evidence from Historical Prices

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ABSTRACT

India is one of the leading producers and consumers of vegetable oils in the world. The integration of 'India's edible oils markets with international oil markets (Rotterdam market) is studied with the overall objective of establishing long-run relationship and direction of causality. Keeping in view of the quantum of arrivals, five major domestic wholesale markets and one international market each for groundnut, soybean, and sunflower were selected. Johansen's cointegration test revealed the prevalence of long-run relationships across the markets. In the case of groundnut oil, Rotterdam market prices are influenced by only Delhi market, whereas all selected domestic markets influence the latter. The results of causality in soybean markets confirmed a unidirectional relationship between all the domestic markets with the international market except Jaipur market, which has a bidirectional relationship with the international market. Hyderabad and Vijayawada sunflower market prices influenced the international market. The suggested policy intervention is to strengthen market intelligence for farmers by establishing online market analysis and dissemination system. The development/strengthening of market infrastructure, including communication, transportation, and storage networks, is mandatory to fully integrate the markets.

Highlights

- Market integration occurs when prices among different locations exhibit similar patterns over an extended period.
- The integration of 'India's edible oils markets with international oil markets (Rotterdam market) is studied with the overall objective of establishing long-run relationship and direction of causality.
- The development/strengthening of market infrastructure, including communication, transportation, and storage networks, is mandatory to fully integrate the markets.

Keywords: Vegetable oil, cointegration, price, markets, causality

Oilseeds sector is one of the sunrise segments of world production, consumption, and income earnings of farmers for the past four decades. These crops are considered the building blocks of rural economy. It is imperative to understand edible oilseeds market linkages to sustain the oilseeds production achievements attained during early '1990's by way of "Yellow Revolution". Oilseeds have become one of the backbone crops of the agricultural economy of India since independence.

Demand projections of vegetable oils in India by the terminal year of XII Plan (2017) were made by different agencies/researchers in the recent past, which is likely to be at least 16 kg/year per capita. However, the actual per capita oil consumption has surpassed 19 kg per annum for the same year. India is one of the leading producers and consumers of vegetable oils in the world. Edible Oil consumption

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is somewhat higher in Western India and lesser in Southern India, albeit, it is more or less proportional to the population distribution. On a comparative basis, palm oil is not much favored by North India. In contrast, South India prefers sunflower oil and is less inclined towards soybean and mustard oils.

The country's consumption has been increasing due to changed food habits, affordability, and the raising percentage of working middle-class urban population percentage. Solvent Extractors Association of India reports that import of vegetable oils during November-December 2020 at 2459 thousand tonnes was about 2 lakh tonnes more compared to the same period in 2019. Karnataka, Andhra Pradesh, Tamil Nadu, and Uttar Pradesh are the oilseed bowl of India. Among the nine significant oilseeds cultivated in India, Karnataka is a leading producer of sunflower, second position in safflower, third position for sesame, and fourth in groundnut crop. Karnataka is the ninth and sixth most extensive state in production and area of oilseeds crops in the country, respectively, with a productivity of 824 kg per hectare (Nayak *et al.* 2020). Although oilseed production is concentrated in a few states, consumers are distributed across urban and rural areas. Therefore, price dissemination and feedback are essential for market price discovery in the spot market. The market integration is researched for oilseed crops to understand the pattern of relationship prevailing in important leading markets.

Market integration occurs when prices among different locations exhibit similar patterns over an extended period. When markets are integrated, a given change in the price of one market could help predict prices of other markets. Thus, market integration explains how different markets are related to each other concerning price of a commodity or related commodity. If prices in two markets converge, it shows the degree of price transmission and the speed at which information travels between two markets. Well-integrated markets follow 'Law of one price' where in the difference in prices is equal to the commodity's cost of transportation from one market to another (Nayak *et al.* 2020). The literature on cointegration techniques, which concerns the market integration of agricultural commodities, especially about oilseeds in India (Akshata *et al.* 2013; Gracy *et al.* 2013; Sundaramoorthy 2014; Sangeetha *et al.* 2017; Nayak *et al.* 2020) reveals presence of perfect market integration and price transmission are crucial for efficient management of marketing system.

Considering the above issues in view, an effort has been made in this paper to analyze the integration of edible oil markets at both national and international level with the overall objective to check the long-run relationship and short-run relationship and the direction of causality among selected vegetable oil markets. Considering India as a major importer and consumer of edible oils, the price behavior of domestic and international reference markets is worth researching. Such studies help in identifying lead markets for framing suitable edible oil import policy of India.

MATERIALS AND METHODS

The study uses time-series data on prices of groundnut, sunflower, and soybean oil in domestic and international markets. The markets selected for the study from India were Chennai, Delhi, Hyderabad, Mumbai, and Rajkot for groundnut, Hyderabad, Bengaluru, Jaipur, Mumbai, and Bhopal for soybean, Bengaluru, Chennai, Hyderabad, Nagpur, Vijaywada for sunflower and one international market for each crop. Monthly price data for selected domestic markets were collected from the website of NIC and the international prices from the Global Economic Monitor (GEM), popularly known as the pink data sheet of the World Bank for Jan- 2009 to Feb- 2020. Various statistical/time-series analytical techniques, namely ADF unit root test, Johansen's cointegration test, and Granger causality test method, were employed to study the market integration.

Steps in Co-integration Analysis

1. Check for stationarity

The static data is the one that has a basic statistical property of constant mean and finite constant variance. The stationarity test is based on the Dickey-Fuller value statistic of β_1 given by the following equation:

$$\Delta P_t = \beta_0 + \beta_1 P_{t-1} + \sum_{k=1}^{N} \delta_k \Delta P_{t-k} + \eta_t \qquad \ldots(1)$$

Where, $\Delta P_t = P_{1t} - P_{1t-1}$

The test statistic is simply the *t* statistic. The values obtained can be compared with critical values given by Dickey Fuller table. For example, in estimating equation (1) the null hypothesis is Ho: P_t is I (1), which is rejected [in favour of I (0)] if β_1 is found to be negative and statistically significant, the above test can also be carried out for the first difference of the variables.

$$\Delta^2 P_t = \theta_0 + \theta_1 \Delta P_{t-1} + \sum_{k=1}^{N} \Phi_k \Delta^2 P_{t-k} + \mu_t \quad \text{...(2)}$$

Where the null hypothesis is Ho: P_t is I (2), which is rejected [in favor of I (1)] if θ_1 is found to be negative and statistically significant.

2. If the data series is non-stationary, make it stationary

If the given data series is already stationary, i.e., if I(0) for both the series, then we say they are not co-integrated; if not, make the data stationary by differencing. Test the differenced series for stationarity by repeating the above step.

3. Determine the order of integration

A series, which becomes stationary after first differencing, is said to be integrated into order one and expressed as I(1). Generally, a series may have been differenced 'd' times to become stationary in which case it is termed as I(d). A major difference between I(0) and I(d) series is that the I(0) series has a finite mean and variance, while in the I(d) series, these magnitudes do not exist. Thus, a differenced series has properties such as mean, standard deviation, and co-variance invariant with time.

If the order of integration is the same for both the series i.e., P_t ~ I (d).for ex: if P_{it} (2) and P_{ij} (2), then test for Co-integration. If the integration order is not the same for the two series, i.e., P_{it}(1), P_{ij}(2) then it is concluded that the series is not co-integrated. Having established that the variables are stationary at level, we may then test for cointegration.

4. Test for cointegration

The Engle-Granger two-step method was used to test for co-integration between the variables. Johansen's Co-integration technique was used to test the long-run relationship.

Engle-Granger methodology

This methodology is based on OLS regression. It is most suitable for bivariate settings where the choice of the dependent variable is not a question and can identify only one cointegration vector. This is a residual-based cointegration test. It seeks to determine whether the residuals of the equilibrium relationship are stationary i.e. $\beta' x_t = e_t$. Is e_t stationary? This is established through the Augmented Dickey Fuller (ADF) test on residuals of the co-integrating regression results.

Procedure adopted for cointegration analysis

Step 1: Pre-test the variables for the presence of unit roots and order of integration. If price series in both markets are stationary, it is unnecessary to proceed since standard time series methods apply to static variables. On the other hand, if the variables are integrated of different orders, it is possible to conclude that they are not co-integrated in the usual sense of the term.

Step 2: Estimate the long-run relationship. If the results of step 1 indicate that both y_t and z_t are I(1), the next step is to estimate the long-run equilibrium relationship in the form,

$$y_t = \beta_0 + \beta_1 z_t + e_t \quad \text{...(3)}$$

run OLS and save the residuals. When y_t and z_t are co-integrated OLS regression yields a consistent estimator of the cointegrating parameters β_0 and β_1. The OLS estimates of β_0 and β_1 converge faster than in OLS models using static variables (Stock, 1987).

Step 3: Test the residuals to determine if the series are co-integrated in a real sense. These residuals are the estimated values of the deviations from the long-run relationship. If these deviations are found to be stationary, the y_t and z_t sequences are co-integrated of order (1, 1). It would be convenient to perform Dickey-Fuller test on the residuals to determine the order of integration. Fit the model

$$\Delta e_t = \alpha_1 e_{t-1} + \epsilon_t \quad \text{...(4)}$$

The null and alternate hypotheses are,

H_0: $\alpha_1 = 0$

H_1: $\alpha_1 \neq 0$

The parameter of interest in equation (4) is α_1. If the null hypothesis $\alpha_1 = 0$, is not rejected, it could be concluded that the residual series contains a unit root. Thus, the y_t and z_t sequences are not co-integrated. Instead, the rejection of null hypothesis implies that the residual sequence is stationary. Given that y_t and z_t are found to be I(1), and the residuals are stationary, it is concluded that the series are co-integrated of order (1, 1).

Step 4: Estimate the Error Correction Model. If the null hypothesis is rejected in Step 3, the residuals from the equilibrium regression ($y_t = \beta_0 + \beta_1 z_t + e_t$) can be used to estimate the Error Correction Model. If y_t and z_t sequences are co-integrated of order (1, 1), the variables have the error correction form,

$$\Delta y_t = \alpha_1 + \alpha_y (y_{t-1} - \beta z_{t-1}) + \sum \alpha_{11}(i)\Delta y_{t-i} + \sum \alpha_{12}(i)\Delta z_{t-i} + \varepsilon_{yt} \quad \ldots(5)$$

$$\Delta z_t = \alpha_2 + \alpha_z (y_{t-1} - \beta z_{t-1}) + \sum \alpha_{21}(i)\Delta y_{t-i} + \sum \alpha_{22}(i)\Delta z_{t-i} + \varepsilon_{yt} \quad \ldots(6)$$

Where, β_i = the parameters of the co-integrating vector given by equation (3).

ε_{yt} and ε_{zt} = White noise disturbances.

$\alpha_1, \alpha_2, \alpha_y, \alpha_z, \alpha_{11}(i), \alpha_{12}(i), \alpha_{21}(i)$ and $\alpha_{22}(i)$ are all parameters.

The items in parentheses are the error correction terms.

Establishing the long-run relationship

Johansen (1988) has developed a multivariate system of equations approach. The long- rum run relationship between the price series is estimated through Johansen co- integration model. The test shows whether the selected vegetable oil markets are integrated or not. This test allows for simultaneous adjustment of more than two variables. Only when two series are integrated can there be a feedback mechanism of price information and market price discovery.

RESULTS AND DISCUSSION

Before analysing cointegration, it is necessary to check the univariate time-series data generating process to examine whether the series under study exhibit a standard stochastic dynamic process. This was analyzed by employing the ADF test, and results are presented in Table 1. The null hypothesis of non-stationarity was tested based on the critical values given by MacKinnon. The result showed that all the market prices had unit roots and concluded that all the price series are non-stationary at their level, and the data became stationary after the first differencing. This implies that all the markets are integrated of the same order I(1) and thus, share a standard long-run dynamic process. These findings are supported by Sangeetha *et al.* (2017) pertaining to observation of groundnut markets integration.

Table 1: Augmented Dickey-Fuller tests for selected oil markets

Sl. No.	Markets	ADF test value		
		Level	1st difference	Critical Value (1%)
	Groundnut			
1	Chennai	-2.033	-11.057	
2	Delhi	-1.889	-13.201	-3.480
3	Hyderabad	-2.629	-10.145	
4	Mumbai	-2.287	-12.175	
5	Rajkot	-2.203	-10.760	
6	Groundnut oil ($/mt)	-2.005	-6.691	
	Soybean			
1	Hyderabad	1.480	10.940	
2	Bengaluru	1.690	11.746	-3.480
3	Jaipur	1.416	11.291	
4	Mumbai	2.493	15.873	
5	Bhopal_MP	2.311	17.707	
6	Soybean oil ($/mt)	-1.396	-8.029	
	Sunflower			
1	Bengaluru	1.461	10.060	
2	Chennai	1.890	12.575	-3.480
3	Hyderabad	2.090	12.352	
4	Nagpur	-1.592	-04.807	
5	Vijaywada	3.295	06.799	
6	Sunflower oil ($/mt)	-1.334	-9.258	

Johansen's Maximum Likelihood Test (trace test) results are shown in Table 2. The trace test statistics value results showed that test statistic value 99.79 was greater than the MacKinnon table value (95.75), which indicated the presence of at least one co-integrating equation at five percent level of significance. This implies that there exists a long-run dynamic equilibrium relationship among the selected markets of groundnut. Therefore, any

Table 2: Johansen's Co-integration Test for Selected Groundnut Markets

Unrestricted Co-integration Rank Test (Trace)				
Hypothised No of CE(s)	**Eigen value**	**Trace Statistic**	**0.05 Critical Value**	Prob.**
None *	0.243	99.79	95.75	0.0256
At most 1	0.199	63.88	69.82	0.1358
At most 2	0.167	35.31	47.86	0.4318
At most 3	0.061	12.13	29.80	0.9273
At most 4	0.031	4.12	15.50	0.8922
At most 5	0.001	0.11	3.84	0.7461

** denotes rejection of the hypothesis at the 0.05 level; **MacKinnon-Haug-Michelis (1999) p-values.*

Table 3: Granger causality test for different groundnut markets

Null Hypothesis	F-Statistic	Prob.	Reject H_0
CHENNAI does not Granger Cause ROTTERDAM	0.57167	0.566	Accepted
ROTTERDAM does not Granger Cause CHENNAI_OIL_	0.43062	0.651	Accepted
DELHI does not Granger Cause ROTTERDAM	4.36418	0.015	Rejected
ROTTERDAM does not Granger Cause DELHI_OIL_	2.78828	0.065	Accepted
HYDERABAD does not Granger Cause ROTTERDAM	2.90525	0.058	Accepted
ROTTERDAM does not Granger Cause HYDERABAD_OIL_	0.87888	0.418	Accepted
MUMBAI does not Granger Cause ROTTERDAM	0.08547	0.918	Accepted
ROTTERDAM does not Granger Cause MUMBAI_OIL_	0.69944	0.499	Accepted
RAJKOT does not Granger Cause ROTTERDAM	1.00267	0.370	Accepted
ROTTERDAM does not Granger Cause RAJKOT_OIL_	1.72069	0.183	Accepted
DELHI does not Granger Cause CHENNAI_OIL_	1.07677	0.344	Accepted
CHENNAI does not Granger Cause DELHI_OIL_	8.46487	0.000	Rejected
HYDERABAD does not Granger Cause CHENNAI_OIL_	0.26513	0.768	Accepted
CHENNAI does not Granger Cause HYDERABAD_OIL_	8.40842	0.000	Rejected
MUMBAI does not Granger Cause CHENNAI_OIL_	10.9200	0.000	Rejected
CHENNAI does not Granger Cause MUMBAI_OIL_	3.12952	0.047	Rejected
RAJKOT does not Granger Cause CHENNAI_OIL_	7.19691	0.001	Rejected
CHENNAI does not Granger Cause RAJKOT_OIL_	2.37205	0.097	Accepted
HYDERABAD does not Granger Cause DELHI_OIL_	10.2754	0.000	Rejected
DELHI does not Granger Cause HYDERABAD_OIL_	3.31226	0.040	Rejected
MUMBAI does not Granger Cause DELHI_OIL_	9.64634	0.000	Rejected
DELHI does not Granger Cause MUMBAI_OIL_	0.59141	0.555	Accepted
RAJKOT does not Granger Cause DELHI_OIL_	7.37011	0.001	Rejected
DELHI does not Granger Cause RAJKOT_OIL_	0.82737	0.440	Accepted
MUMBAI does not Granger Cause HYDERABAD_OIL_	5.54297	0.005	Rejected
HYDERABAD does not Granger Cause MUMBAI_OIL_	1.32749	0.269	Accepted
RAJKOT does not Granger Cause HYDERABAD_OIL_	5.22806	0.007	Rejected
HYDERABAD does not Granger Cause RAJKOT_OIL_	5.16547	0.007	Rejected
RAJKOT does not Granger Cause MUMBAI_OIL_	0.84487	0.432	Accepted
MUMBAI_ does not Granger Cause RAJKOT_OIL_	5.85981	0.004	Rejected

price shocks in these selected markets would be transmitted across the other markets.

A Granger causality test was also performed across the groundnut markets; the results of which are given in Table 3 and Fig. 1. According to the Granger causality test, there were bidirectional causalities between Mumbai-Chennai, Hyderabad-Rajkot, Delhi-Hyderabad and the former market in each pair granger causes the wholesale price formation in the latter market, which in turn provides the feedback to the former market as well. The remaining market pairs showed unidirectional causalities, meaning that a price change in the former market in each pair granger causes the price formation in the latter

Table 4: Johansen's Co-integration Test for Selected Soybean Markets

Unrestricted Cointegration Rank Test (Trace)				
Hypothised No of CE(s)	**Eigen value**	**Trace Statistic**	**0.05 Critical Value**	Prob.**
None *	0.269902	100.3232	95.75366	0.0233
At most 1	0.205410	59.74289	69.81889	0.2433
At most 2	0.115155	30.08200	47.85613	0.7148
At most 3	0.058111	14.29982	29.79707	0.8234
At most 4	0.044690	6.576912	15.49471	0.6273
At most 5	0.005250	0.679073	3.841466	0.4099

** denotes rejection of the hypothesis at the 0.05 level; **MacKinnon-Haug-Michelis (1999) p-values.*

Table 5: Granger causality test for different Soybean markets

Null Hypothesis	F-Statistic	Prob.	Reject H_0
BENGALURU_OIL_ does not Granger Cause ROTTERDAM	3.93415	0.022	Rejected
ROTTERDAM does not Granger Cause BENGALURU_OIL_	1.46498	0.235	Accepted
BHOPAL_MP__OIL_ does not Granger Cause ROTTERDAM	6.98276	0.0013	Rejected
ROTTERDAM does not Granger Cause BHOPAL_MP__OIL_	0.43974	0.6452	Accepted
HYDERABAD_OIL_ does not Granger Cause ROTTERDAM	3.60385	0.03	Rejected
ROTTERDAM does not Granger Cause HYDERABAD_OIL_	2.15690	0.1199	Accepted
JAIPUR_OIL_ does not Granger Cause ROTTERDAM	5.93923	0.0034	Rejected
ROTTERDAM does not Granger Cause JAIPUR_OIL_	4.94259	0.0086	Rejected
MUMBAI_OIL_ does not Granger Cause ROTTERDAM	4.41069	0.0141	Rejected
ROTTERDAM does not Granger Cause MUMBAI_OIL_	0.07054	0.9319	Accepted
BHOPAL_MP__OIL_ does not Granger Cause BENGALURU_OIL_	0.59885	0.551	Accepted
BENGALURU_OIL_ does not Granger Cause BHOPAL_MP__OIL_	8.79795	0.0003	Rejected
HYDERABAD_OIL_ does not Granger Cause BENGALURU_OIL_	1.16719	0.3146	Accepted
BENGALURU_OIL_ does not Granger Cause HYDERABAD_OIL_	5.36769	0.0058	Rejected
JAIPUR_OIL_ does not Granger Cause BENGALURU_OIL_	0.12847	0.8796	Accepted
BENGALURU_OIL_ does not Granger Cause JAIPUR_OIL_	1.52518	0.2215	Accepted
MUMBAI_OIL_ does not Granger Cause BENGALURU_OIL_	3.61005	0.0299	Rejected
BENGALURU_OIL_ does not Granger Cause MUMBAI_OIL_	0.50300	0.6059	Accepted
HYDERABAD_OIL_ does not Granger Cause BHOPAL_MP__OIL_	5.20596	0.0067	Rejected
BHOPAL_MP__OIL_ does not Granger Cause HYDERABAD_OIL_	0.84331	0.4327	Accepted
JAIPUR_OIL_ does not Granger Cause BHOPAL_MP__OIL_	7.98067	0.0005	Rejected
BHOPAL_MP__OIL_ does not Granger Cause JAIPUR_OIL_	0.41911	0.6585	Accepted
MUMBAI_OIL_ does not Granger Cause BHOPAL_MP__OIL_	2.35840	0.0987	Accepted
BHOPAL_MP__OIL_ does not Granger Cause MUMBAI_OIL_	0.30793	0.7355	Accepted
JAIPUR_OIL_ does not Granger Cause HYDERABAD_OIL_	1.82243	0.1658	Accepted
HYDERABAD_OIL_ does not Granger Cause JAIPUR_OIL_	0.95545	0.3874	Accepted
MUMBAI_OIL_ does not Granger Cause HYDERABAD_OIL_	9.21197	0.0002	Rejected
HYDERABAD_OIL_ does not Granger Cause MUMBAI_OIL_	2.43190	0.092	Accepted
MUMBAI_OIL_ does not Granger Cause JAIPUR_OIL_	6.24005	0.0026	Rejected
JAIPUR_OIL_ does not Granger Cause MUMBAI_OIL_	1.62518	0.2009	Accepted

Table 6: Johansen's Co-integration Test for Selected Sunflower Markets

Unrestricted Co integration Rank Test (Trace)				
Hypothised No of CE(s)	**Eigen value**	**Trace Statistic**	**0.05 Critical Value**	Prob.**
None *	0.422170	156.3347	95.75366	0.0000
At most 1 *	0.213261	85.58138	69.81889	0.0017
At most 2 *	0.168814	54.63962	47.85613	0.0101
At most 3 *	0.148552	30.78737	29.79707	0.0383
At most 4	0.062311	10.04196	15.49471	0.2775
At most 5	0.013417	1.742539	3.841466	0.1868

** denotes rejection of the hypothesis at the 0.05 level; **MacKinnon-Haug-Michelis (1999) p-values.*

market. In contrast, the price change in the latter market is not flowed back for the price change in the former market in each pair. Delhi market didn't influence any domestic market but was influenced by all other selected markets at the same time influencing the international market (Rotterdam price). These findings agree with Venujayakanth *et al*. (2017), who observed the integration between three groundnut domestic markets.

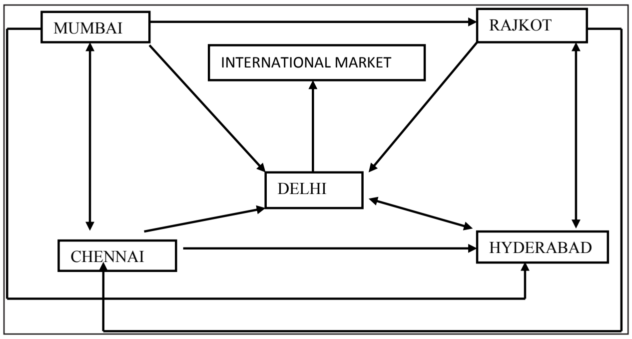

Fig. 1: Causal relationship among major groundnut markets under study

The, Johansen's cointegration test has shown that even though the selected wholesale soybean markets are geographically and spatially isolated, they are well-connected in terms of prices of soybean, revealing the presence of long-run price linkages among the soybean markets.

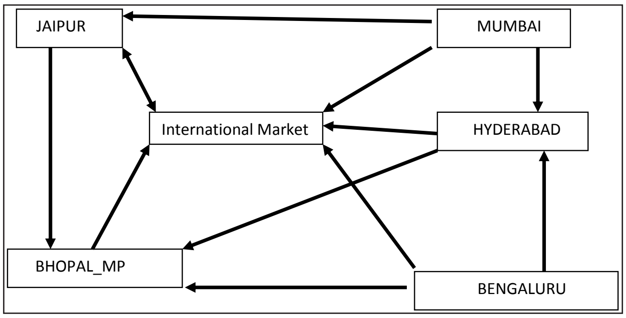

Fig. 2: Causal relationship among major soybean markets understudy

After finding cointegration among different soybean markets, Granger causality was also estimated between the selected pairs of soybean oil markets. The Granger causality shows the direction of price formation between two markets. The results are presented in Table 5 and visualized in Fig. 2. According to Granger causality test, there are unidirectional causalities between the selected soybean oil market pairs: Bengaluru market of Karnataka Granger cause price formation in Hyderabad and Bhopal markets in Madhya Pradesh whereas Hyderabad market Granger cause price formation in Bhopal market. Mumbai market Granger cause price formation in Hyderabad and Jaipur markets, whereas Jaipur market Granger cause price formation in Bhopal market. A unidirectional relationship between all the domestic markets with international markets except the Jaipur market, which has a bidirectional relationship with international market.

The integration relation between the wholesale prices of selected sunflower markets and the relationship between wholesale prices of selected sunflower markets was examined and presented in Table 6. The results revealed the presence of four co-integrating equations at a five percent level of significance. Hence, it is concluded that long-run equilibrium exists among selected sunflower markets.

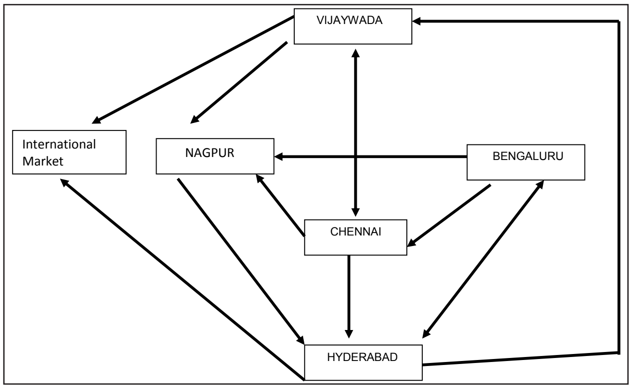

Fig. 3: Causal relationship among major sunflower markets under study

As a part of cointegration analysis, Granger Causality test was conducted to examine whether there was a causal relationship between the co-integrated markets as revealed by Johansen's test. The causal relationships among major sunflower oil market prices were approached through Granger's causality technique. The results depicted in Table 7 and the direction of causality in Fig. 3 revealed bidirectional and unidirectional relationships among the selected sunflower oil markets. The results confirmed bidirectional causalities between the sunflower oil market pairs: Vijaywada-Chennai and Bengaluru-Hyderabad oil markets. The remaining market pairs showed unidirectional causalities. Hyderabad market influences only the Vijayawada market. However, it is influenced by

Table 7: Granger causality test for different Sunflower markets

Null Hypothesis	F-Statistic	Prob.	Reject H_0
BENGALURU_OIL_ does not Granger Cause ROTTERDAM	1.80104	0.1693	Accepted
ROTTERDAM does not Granger Cause BENGALURU_OIL_	1.54681	0.2169	Accepted
CHENNAI_OIL_ does not Granger Cause ROTTERDAM	2.79374	0.065	Accepted
ROTTERDAM does not Granger Cause CHENNAI_OIL_	2.83644	0.0624	Accepted
HYDERABAD_OIL_ does not Granger Cause ROTTERDAM	5.64484	0.0045	Rejected
ROTTERDAM does not Granger Cause HYDERABAD_OIL_	0.43868	0.6459	Accepted
NAGPUR_OIL_ does not Granger Cause ROTTERDAM	1.46732	0.2344	Accepted
ROTTERDAM does not Granger Cause NAGPUR_OIL_	1.64876	0.1964	Accepted
VIJAYWADA_OIL_ does not Granger Cause ROTTERDAM	4.88616	0.009	Rejected
ROTTERDAM does not Granger Cause VIJAYWADA_OIL_	0.37829	0.6858	Accepted
CHENNAI_OIL_ does not Granger Cause BENGALURU_OIL_	0.97235	0.381	Accepted
BENGALURU_OIL_ does not Granger Cause CHENNAI_OIL_	4.96308	0.0084	Rejected
HYDERABAD_OIL_ does not Granger Cause BENGALURU_OIL_	7.63065	0.0007	Rejected
BENGALURU_OIL_ does not Granger Cause HYDERABAD_OIL_	3.57740	0.0308	Rejected
NAGPUR_OIL_ does not Granger Cause BENGALURU_OIL_	0.55555	0.5751	Accepted
BENGALURU_OIL_ does not Granger Cause NAGPUR_OIL_	4.60852	0.0117	Rejected
VIJAYWADA_OIL_ does not Granger Cause BENGALURU_OIL_	2.13582	0.1224	Accepted
BENGALURU_OIL_ does not Granger Cause VIJAYWADA_OIL_	2.40282	0.0946	Accepted
HYDERABAD_OIL_ does not Granger Cause CHENNAI_OIL_	1.15968	0.3169	Accepted
CHENNAI_OIL_ does not Granger Cause HYDERABAD_OIL_	3.73693	0.0265	Rejected
NAGPUR_OIL_ does not Granger Cause CHENNAI_OIL_	0.26592	0.7669	Accepted
CHENNAI_OIL_ does not Granger Cause NAGPUR_OIL_	7.11090	0.0012	Rejected
VIJAYWADA_OIL_ does not Granger Cause CHENNAI_OIL_	3.28418	0.0407	Rejected
CHENNAI_OIL_ does not Granger Cause VIJAYWADA_OIL_	3.19177	0.0444	Rejected
NAGPUR_OIL_ does not Granger Cause HYDERABAD_OIL_	4.14691	0.018	Rejected
HYDERABAD_OIL_ does not Granger Cause NAGPUR_OIL_	0.31718	0.7288	Accepted
VIJAYWADA_OIL_ does not Granger Cause HYDERABAD_OIL_	1.24914	0.2903	Accepted
HYDERABAD_OIL_ does not Granger Cause VIJAYWADA_OIL_	15.0840	1.00E-06	Rejected
VIJAYWADA_OIL_ does not Granger Cause NAGPUR_OIL_	4.36522	0.0147	Rejected
NAGPUR_OIL_ does not Granger Cause VIJAYWADA_OIL_	2.69828	0.0712	Accepted

the other three markets: Chennai, Nagpur, and Bengaluru oil markets. Vijayawada, Chennai, and Bengaluru oil influences the price formation in Nagpur markets. Bangalore market influences price formation in the Chennai market. On the other hand, only Hyderabad and Vijayawada markets are influencing the international market (Rotterdam). Similar results were obtained by Gracy *et al.* (2013) and Vasudeva and Sujatha (2012).

CONCLUSION

The study investigates the stationarity and cointegration in major groundnut, sunflower, and soybean oil markets of India and the international market. The study examines the market integration in five selected domestic markets and one international market for each selected crop using Johansen's cointegration test and Granger Causality test. Unit root test showed non-stationary of price series at their levels, and it became stationary after the first differences. Johansen's cointegration test has shown that even though the selected wholesale oil markets are geographically separated and spatially segmented, they are well-connected in terms of oil prices of all selected crops, demonstrating that the selected oil markets have long-run price linkages. The outcome of the Granger causality test, confirmed unidirectional and bidirectional causalities between the selected oilseed market pairs. In the case of groundnut, Rotterdam (International) market is influenced by only the Delhi market while all selected domestic markets influence the latter. The causality results in soybean markets affirmed the unidirectional influence of domestic markets on the international market except for Jaipur market, which has a bidirectional relationship with the international market. In the case of sunflower, only Hyderabad and Vijayawada markets are influencing the international market prices. The suggested policy intervention calls for faster movement of market information through strengthening market intelligence and establishing an online marketing system through networking. Development/ strengthening of market infrastructure, including communication, transportation, and storage facilities, is the need of the hour to integrate the market prices fully.

REFERENCES

Akshata, N., Gracy, C.P., Nagashree, N. and Jyoti, N. 2013. Growth of sunflower production in India - a comparative analysis, *Mysore J. Agric. Sci.*, **47**(3): 628-634.

Gracy, C.P., Akshata, N., Nagashree, N. and Girisha, K. 2013. Sunflower market cointegration analysis - a market intelligence tool for marketing decisions. *Mysore J. Agric. Sci.*, **47**(4): 835-839.

Nayak, A., Lokesha, H. and Gracy, C.P. 2020. Co-integration of Groundnut Markets in India with Special Reference to Karnataka State, *Curr. J. Appl. Sci. Technol.*, **39**(18): 14-22.

Nayak, A., Lokesha, H. and Gracy, C.P. 2020. Market Integration of Major Oilseeds and Vegetable Oils in India- Evidence from Karnataka. *Int. J. Agri. Env. Biotech.*, **13**(4): 01-08.

Sangeetha, R., Ramanand, M.S. and Menaka, S. 2017. An Econometric Analysis on Groundnut Markets in India, *Int. J. Curr. Microbiol. Appl. Sci.*, **6**(8): 2131-2142.

Shruti, M., Singh, J. and Kumar, S. 2018. Cointegration among major cauliflower markets in Punjab. *Indian J. Econ. Dev.*, **14**(2): 330-335.

Sundaramoorthy, C., Girish, K.J., Suresh Pal and Mathur, V.C. 2014. Market integration and volatility in edible oil sector in India, *J. Indian Soc. Agric. Stat.*, **68**(1): 67-76.

Suresh, B. and Anilkumar B. Kote, 2012, Anempirical analysis of marketing of oilseeds in Haveri district of Karnataka state of India. *Int. J. Curr. Res. Rev.*, **4**(11): 16-29

Vasudeva, N.K. and Sujata, S. 2012, Integration of sunflower markets in South Karnataka. *J. Progress. Agric.*, **3**(2): 97-98.

Venujayakanth, B., Dudhat, A.S., Swaminathan, B. and Ardeshana, N.J. 2017. Price integration analysis of major groundnut domestic markets in India. *Econ. Aff.*, **62**(2): 233-241.