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Inter Commodity Price Linkages in India: A Case of Foodgrains, Oilseeds and Edible Oils

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The main objective of this paper is to analyze the nature of price inter-linkages among four commodity complexes, namely cereals, pulses, oil seeds and edible oils. The co-integration and error-correction analysis in the case of cereals led to the conclusion that there was a unique relationship among wheat, rice and spiked millet while great millet, maize, barley and finger millet did not belong to the cereals common market. Among pulses, lentil, green gram and Bengal gram constituted a single common market. In the case of oilseeds, only groundnut, mustard, sunflower and soybean belonged to the common market. In edible oils, groundnut, rape-seed-mustard and coconut formed a common market in the long run. In the late 1990's, prices of oilseeds drifted away from the long-run equilibrium path because of a short period disturbance in the oilseeds market. However, the drift was not visible in the case of edible oils plausibly because of the presence of imported edible oils. The diversions were least for cereals and to some extent for pulses, evidently because of the cushion available in terms of procurement and minimum support price policy of Government of India in their cases.

Keywords: Price Linkages, Commodity Complexes, Co-integration, Error-correction

1. INTRODUCTION

Given the tastes and preferences, consumers generally switch their consumption among the substitute commodities in response to any price change. Thereby, any shortage of a particular commodity in the market results into rise in demand for the substitute commodities subsequently increasing the price of substitutes. Thus, this process of substitution gives rise to arbitrage, which ultimately ensures that the law of one price (LOP) holds for close substitutes (Stigler 1969). [1] The LOP holds for a group of prices when prices move proportionally to each other over time, that is, markets for that group are integrated (Asche et al. 1999). Therefore, it becomes important to know how the movements in the price of one substitute are transmitted to the others. The understanding of transmission of price signals from one commodity to another and their degree of association is central to stabilizing prices of various commodities. In a perfectly competitive market, prices of two perfect substitutes should move in unison in response to the forces of demand and supply. The accuracy and speed with which prices of different commodity substitutes adjust in the market is taken as an index of interdependence among these commodity groups. The main objective of this paper is to analyze the nature of price inter-linkages among agricultural commodities in India. To work out the price linkages the commodity complexes considered in this paper are cereals, pulses, oilseeds and edible oils.

Among the cereals, there are two major grains, namely wheat and rice, which form the staple diet of average Indians. There are five other coarse grains, which substitute (or

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[1] A number of studies in the recent past have used time series techniques to test for price interdependence, see e.g., Stigler and Sherwin (1985), Benson and Faminow (1990), Nasurudeen and Subramanian (1995), Owen et.al. (1997), Asche et al. (1997, 1999)

supplement) the consumption of these two superior cereals especially in the case of the poor. These coarse grains are great millet, spiked millet, maize, barley and finger millet. Among cereals, rice dominates in production with its overwhelming share (45 per cent). However, over the years, the composition of cereals has undergone a significant change. The growing importance of wheat in the total basket of cereals is evident in recent years from its rising share in production from 14 per cent in 1949-50 to 37 per cent during the period 1999-01. On the other hand, the share of coarse grains has come down drastically — from 36 per cent to 18 per cent during the same period. There is a marginal decline in the share of rice also during this period (from 50 per cent in 1949-50 to 45 per cent during 1999-01). From these changes in the composition of cereals, it is apparent that the declining shares of coarse grains and rice have given way to increased importance of wheat. Since wheat is a close substitute for coarse grains it is likely that when there is a shortfall in the production of cereals, particularly coarse grains, the pressure of adjustment in demand falls on wheat (Sharma et al. 2000).

Similar changes have also occurred in the case of oilseeds and their composition has undergone a significant change over time. Among oilseeds, groundnut still stands out as the leading oilseed crop, despite a significant reduction in its share in total oilseeds from 64 per cent during 1951-53 to 31 per cent during 1999-01. But soybean, which had a tiny share in oilseeds until the 1970s, is the second most important oilseed crop with a share of 30 per cent during 1999-01. In terms of oil, rapeseed-mustard is still the second most important crop after the groundnut accounting for about 24 per cent of the total oilseeds production and about 31 per cent share of the total edible oils. The remaining oilseeds together account for 14 per cent share of the total oilseeds production (Sharma and Kumar 2001).

However, unlike cereals and oilseeds, a very meager change has been observed in the composition of pulses during the period of last 50 years. Bengal gram remains the largest crop in pulses with marginal decline in its share from 43 percent in 1950-51 to 38 percent in 2001-02. Black gram and red gram, the other two major pulses have maintained their share at around 25 and 20 percent, respectively during this time period. The remaining 18 percent share is contributed by other *rabi*/*kharif* pulses namely green gram and lentil.

Thus, changes in cereals, pulses and oilseeds complexes point to the fact that being close substitutes within each complex, it is likely that a shortfall in the production of one exerts pressure on the other leading to adjustment in demand patterns[2]. Considering these changes in the composition in each case, it is essential to know the pattern of interdependence among different substitutes. Although these issues are already known, there is very little understanding of transmission of price signals from one commodity to another and their degree of association. Further, the speed with which prices of one commodity adjust to a shock in prices of other commodities in the system is also not known. In the proceeding sections, we try to establish the linkages in the prices of various commodity complexes.

To carry out this analysis we have used monthly wholesale price indices for rice, wheat, great millet, spiked millet, maize, barley and finger millet for the cereals group; Bengal gram, red gram, black gram, green gram and lentil in the pulses group; groundnut seed, rapeseed-mustard, cotton seed, soybean, sunflower, castor seed, kardi, linseed and nigerseed for the oilseeds complex; and groundnut oil, rapeseed-mustard oil, coconut oil, cotton seed oil,

[2] The trends in availability (demand) of above commodity complexes were mostly in line with the trends in production as the net imports (imports-exports) were generally very low in the case of cereals, pulses and oilseeds. The only exception was edible oils in which case the imported edible oils have become quite important in the very recent years (see Annex Table 1).

vanaspati oil, imported edible oil and rice bran oil for the edible oils complex. The data used are monthly wholesale price indices for the period of April 1990 to March 2002.

2. METHODOLOGICAL FRAMEWORK

Since interdependence among prices is related to their current as well as past levels, we employ a multivariate co-integration technique to study price interdependence rather than estimating a structural relationship. A number of studies in the recent past have used time series techniques to test for price interdependence using co-integration technique[3]. Unlike the earlier approaches[4] which ignored time series properties (non-stationarity of the data series), the co-integration methodology captures long run properties also when dealing with the non-stationary data. The fundamental insight of co-integration analysis is that although many economic time series may tend to move upwards or downwards over time in a non-stationary fashion, groups of variables may drift together. If there is a tendency for some linear relationship to hold between a set of variables over a long period of time, such relationships are identified with the help of co-integration technique.

However, the simple co-integration tests developed by Granger (1986) and Engle and Granger (1987) fail to address linkages, which might operate through a third variable and issues such as endogeneity caused by prices that are simultaneously determined. This is due to the fact that these methods were developed in a bi-variate framework. To overcome these limitations, a better and more powerful test for co-integration was developed by Johansen (1988) and Johanson and Juselius (1990). This test is carried out in a Vector Auto Regressive mode and is a reduced form method. This test for co-integration is particularly important when one is dealing with co-integration in a multi-variate framework. The advantage of this method is that it takes care of both endogeneity and simultaneity problems associated with simple co-integration tests.

Under Johansen' procedure, co-integration among the price series is tested using Johansen's (1988) maximum likelihood test based on the error-correction representation:

$$\Delta z_t = \varphi_k \Delta z_{t-k} + \Pi z_{t-1} + \mu + \varepsilon_t \qquad \text{(i)}$$

where z_t is a vector of I(1) processes. The rank of Π equals the number of co-integrating vectors, which is tested by maximum eigenvalue and likelihood ratio test statistics. If there exist co-movements between prices then there is a possibility that they will trend together in finding a long run stable equilibrium relationship. This long run stable equilibrium relationship can be captured by the Granger representation theorem. This theorem states that if a set of variables are co-integrated, then there exists a valid error correction representation of the data.

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[3] See e.g., Stigler and Sherwin (1985), Ardeni (1989), Benson and Faminow (1990), Goodwin and Schroeder (1991), Asche et al. (1997), Bukenya and Labys (2002), Baffes and Gardner (2003), Rashid (2004), Krivonos (2004), Jha et al. (2005).

[4] See, e.g., Jasdanwalla (1966), Cummings (1967), Lelle (1971), Jones (1968, 1972), Kainth (1982), Stigler and Sherwin (1985), Neal (1987).

3. ESTIMATION AND RESULTS

Testing for co-integration at the first step requires testing the order of stationarity of the variables. Integration tests are prerequisite for co-integration. The order of integration (existence or absence of non-stationarity) in the time series was checked by the 'Augmented Dickey-Fuller (ADF) Test' (Dickey and Fuller 1979) and 'Phillips and Perron (PP) Test' (Phillips and Perron, 1988). To determine the lag length, Akaike's AIC criterion (Akaike, 1969) was used. The ADF and PP test results for the four commodity complexes are presented in Tables 1.1 to 1.4.[5] The results of both ADF and PP tests (see Table 1.1) reveal that the price series of rice, wheat, barley and finger millet contained a unit root. However, ADF test rejected the null hypothesis of presence of unit root in the case of great millet, spiked millet and maize while PP test rejected the presence of unit root only in the case of maize. Thus, both the test statistics found maize as a stationary variable in levels while all other cereals were found stationary at first difference. Therefore, maize might not make a long run association with the other cereals. However adopting a more precautionary approach, we also include maize in one co-integration equation to verify whether it forms a part of the common market or not.

Table 1.1. Augumented Dickey Fuller (ADF) and Phillips & Perron (PP) Test for Unit Root for the Cereals (Sample: 1990.04 to 2002. 03)

Series (in Log)	Levels			First Difference	
	ADF	PP		ADF	PP
Log Rice	-2.34	-2.07 (1)		-5.72*	-8.85* (2)
Log Wheat	-1.23	-2.72 (9)		-6.83*	-6.88* (8)
Log Great millet	-4.05*	-2.38 (6)		-3.35**	-7.54* (5)
Log Spiked millet	-3.64*	-2.80 (6)		-4.90*	-8.15* (5)
Log Maize	-5.21*	-2.99** (12)			
Log Barley	-2.34	-2.83 (17)		-5.00*	-8.41* (15)
Log Finger millet	-2.84	-1.96 (4)		-4.25*	-9.10* (3)

Note:
(1) * Significant at the 1% Level, ** Significant at the 5% Level
(2) Numbers in parenthesis are optimum lag lengths determined by Akaike Information Criterion (AIC)

In the case of pulses, it was observed that all the major pulses, viz., Bengal gram, red gram, lentil, green gram and black gram contained a unit root in levels, while they were stationary at first difference (see Table 1.2). As, all the pulses were integrated of order one, all were

[5] The price series used here are monthly price indices in log form. A common problem while analysing price series is the existence of possible underlying common factor. If the common factor dominates the individual variation in the series one could get spurious results of interdependence among different price series. Such a common factor in the present case could be a general upward movement in the price levels. Hence, the experiment is done by deflating the price series by the price index of all commodities. The period of study is from April 1990 to March 2002. The data have been collected from the Government of India publication, Monthly Price Index of All Commodities.

amenable to long run association. In the case of major oilseeds, unit root was observed in all the series (see Table 1.3). Similar results were obtained for the edible oils in which case it was observed that all the seven edible oils contained a unit root in levels (see Table 1.4). Therefore, they might have a long run association in their respective commodity complexes.[6]

Table 1.2. Augumented Dickey Fuller (ADF) and Phillips & Perron (PP) Test for Unit Root for the Pulses (Sample: 1990.04 to 2002.03)

Series (in Log)	Levels		First Differece	
	ADF	PP	ADF	PP
Log Bengal gram	-3.16**	-2.00 (1)	-6.79*	-6.65* (1)
Log Red gram	-2.02	-1.47 (1)	-5.67*	-8.26* (2)
Log Lentil	-2.11	-1.90 (12)	-3.12**	-7.45* (10)
Log Green gram	-1.29	-1.59 (6)	-7.15*	-7.67* (5)
Log Black gram	-1.87	-1.43 (1)	-7.18*	-7.69 (1)

Note:
(1) * Significant at the 1% Level, ** Significant at the 5% Level
(2) Numbers in parenthesis are optimum lag lengths determined by Akaike Information Criterion (AIC)

Table 1.3. Augumented Dickey Fuller (ADF) and Phillips & Perron (PP) Test for Unit Root for the Oilseeds (Sample: 1990.04 to 2002. 03)

Name of the Series	Levels		First Difference	
	ADF	PP	ADF	PP
Log Groundnut seeds	-1.13	-1.65 (6)	-6.92*	-8.54* (5)
Log Rape-mustard seeds	-2.25	-1.47 (11)	-2.88	-6.88* (10)
Log Soybean seeds	-0.97	-1.44 (6)	-7.22*	-10.44* (3)
Log Sunflower seeds	-2.01	-2.27 (2)	-10.27*	-12.25* (1)
Log Castor seeds	-3.03**	-2.44 (1)	-6.15*	-8.66* (4)
Log Cotton seeds	-1.67	-2.79 (5)	-8.77*	-8.79* (4)
Log Kardi seeds	-1.73	-1.51 (1)	-7.62*	-9.18* (1)
Log Lin seeds	-2.38	-1.52 (10)	-4.36*	-9.32* (9)
Log Niger seeds	-3.02**	-2.69 (3)	-6.98*	-10.93* (2)

Note:
(1) * Significant at the 1% Level, ** Significant at the 5% Level
(2) Numbers in parenthesis are optimum lag lengths determined by Akaike Information Criterion (AIC)

[6] Unit root results presented in the tables include only the intercept and not the trend. However, all the variables were tested for unit root including a trend. There was hardly any contradiction between the results of unit root with and without trend.

Table 1.4. Augumented Dickey Fuller (ADF) and Phillips & Perron (PP) Test for Unit Root for the Edible oils (Sample: 1990.04 to 2002.03)

Name of the Series	Levels		First Differece	
	ADF	PP	ADF	PP
Log Groundnut oil	-2.53	-1.42 (11)	-3.14**	-5.93* (10)
Log Rape & mustard oil	-2.11	-3.16 (11)	-3.04**	-3.66** (10)
Log Coconut oil	-0.89	-0.33 (1)	-4.53*	-7.47* (6)
Log Cottonseed oil	-2.14	-1.55 (6)	-4.96*	-8.19* (5)
Log H. *Vanaspati* oil	-2.08	-0.84 (10)	-3.85*	-8.74* (6)
Log Imported Edible oil	0.33	-0.30 (12)	-4.25*	-9.46* (11)
Log Rice Bran oil	-2.06	-1.92 (4)	-10.05*	-10.88* (1)

Note:

(1) * Significant at the 1% Level, ** Significant at the 5% Level

(2) Numbers in parenthesis are optimum lag lengths determined by Akaike Information Criterion (AIC)

4. THE MULTIVARIATE CO-INTEGRATION

After having established that all the cereals with the exception of maize have the same long run characteristics, we proceed for testing co-integration among these variables. Co-integration is tested using Johansen's maximum likelihood procedure based on the error-correction representation as given in equation (i). The rank of Π, i.e., the number of co-integrating vectors is tested by maximum eigenvalue and likelihood ratio test statistics.

The vector of variables in the above equation consists of six real price indices, i.e., wheat, rice, great millet, spiked millet, barley and finger millet in natural logarithms. In a system of six non-stationary variables, we can have six different stochastic trends, one for each variable, while there is a possibility for at the most, five co-integrating vectors, because the system must contain at least one stochastic trend for the variables to be non-stationary by themselves. According to Dickey et al. (1991), "Co-integrating vectors could be thought of as representing constraints that an economic system imposes on the movement of the variables in the system in the long run. Hence, the more co-integrating vectors there are, the more stable the system is."

For any commodity complexes to be integrated in the true sense, they must share a common trend and therefore, should have a common integrating factor. According to Gonzalez and Helfand (2001), for the existence of a common integrating factor among the integrated prices, all the price series must be co-integrated and the rank of Π must be n-1 co-integrating vectors. In other words, in a system of 6 price series, there must exist 5 co-integrating vectors if these prices are to be integrated and should have a common information-sharing path. In a situation in which there are less than 5 co-integrating vectors, there would exist more than one common trend. Supposing there are 4 co-integrating vectors among 6 non-stationary variables, it would mean that at least there exist two common trends[7].

[7] Gonzalez and Helfand methodology was followed by Rashid (2004) and Jha, et.al. (2005) for testing market integration and common markets in the case of maize in Uganda and rice in India, respectively.

In such a situation, some prices could be generated by the first common trend, some by the second and some by a combination of the first and second trends. Such prices can not be characterized as integrated because the long run movements in prices would be governed by different components (Kumar and Sharma 2003).

4.1. Single Common Trend Among Cereals

For searching the commodity combinations that share n-1 co-integrating vectors, Johansen's Reduced Rank Vector Auto Regression has been used as discussed above. The rank of Π is tested by the maximal eigenvalue test (ξ_r), and the trace test (η_r) based on the VAR system. The order of VAR (lag) was determined based on Akaike Information Criterion, Schwarz Bayesian Criterion and Adjusted LR test statistics. Mfit and Eviews software packages were used for the calculations.[8]

To determine which particular cereal belongs to the common market, we start with two variables (wheat and rice) at the first place and test for the number of co-integrating vectors. If there exists one co-integrating vector that means these two variables (wheat and rice) share a common trend. In the next step we add an additional cereal. This additional variable would either share a common trend with the previous two or it would not. If it shares a common trend, there would exist two co-integrating vectors and this additional variable would belong to the common market. If we continue to find only one co-integrating vector that means the additional variable adds another common trend to the system and therefore it does not belong to the common market. In the latter case, we drop this variable and proceed for checking the next variable and so on.

Table 1.5 presents the results of co-integration among the cereals. It is clearly evident from the results of the table that out of six cereals only wheat, rice and spiked millet shared a single common market in the long run. Both the maximum eigenvalue test and the trace test observed two co-integrating vectors (among wheat, rice, and spiked millet). We tried different sequences among these 6 cereals but the results were invariant to the ordering. Great millet, barley and finger millet were not found having any long run association with the other three cereals, viz., wheat, rice and spiked millet. We also included maize in one equation (although maize was observed as stationary variable) but the results confirmed that it was not a component of the long run common market.

Since the co-integration tests are not based on a structural model, it is difficult to interpret the long run elasticities in terms of signs and magnitude given by the co-integration relationship. However, the relative magnitude of different variables in the co-integrating relationship can be important to draw some inferences. However, before doing that we test the significance of different variables in the co-integration vectors. We use the exclusion tests (Johansen and Juselius 1990) to test the null hypothesis that a particular price series is not significant in the co-integration relationship by imposing restriction on long run parameter $\beta = 0$.[9] The CHSQ test statistics were 22.5 (rice), 22.8 (wheat) and 15.3 (spiked

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[8] As the nature of commodities under analysis was not seasonal, seasonal dummies were not included in the co-integration equations. We however checked the ECM equations by including three seasonal (quarter) dummies but observed that in most of the cases their 't' values were not significant and therefore the final results were estimated without including any seasonal dummies in the case of ECMs as well.

[9] Exclusion tests are imposed as null restrictions on the long-run parameters in β. For instance, if prices

millet). The null hypothesis of exclusion was rejected at one-percent significance level in all these price series. Therefore, we conclude from the above that a unique co-integration relationship was verified among wheat, rice and spiked millet.

Table 1.5. Johansen's Maximum Eigenvalue and Trace Test for the Number of Cointegrating Vectors in Cereals (Sample: 1990-04 to 2002-03)

Series in Logarithms	Null Hypothesis	Eigenvalue	Maximum Eigen (ξ_r)	Trace (η_r)	Order of VAR©
Rice, Wheat	r = 0	0.25	40.41*	45.01*	2
	r ≤ 1	0.03	4.59	4.59	
Rice, Wheat, Spiked millet	**r = 0**	**0.19**	**29.21***	**46.85***	**5**
	r ≤ 1	**0.09**	**13.42****	**17.64****	
	r ≤ 2	**0.03**	**4.23**	**4.23**	
Rice, Wheat, Spiked millet, Great millet	r = 0	0.29	49.00*	71.88*	3
	r ≤ 1	0.07	9.62	22.87	
	r ≤ 2	0.06	8.35	13.26	
	r ≤ 3	0.03	4.91	4.91	
Rice, Wheat, Spiked millet, Barley	r = 0	0.21	32.63*	60.53*	4
	r ≤ 1	0.09	13.29	27.90	
	r ≤ 2	0.07	10.70	14.61	
	r ≤ 3	0.03	3.92	3.92	
Rice, Wheat, Spiked millet, Finger millet	r = 0	0.30	50.00*	88.18*	3
	r ≤ 1	0.15	23.58*	38.18*	
	r ≤ 2	0.06	9.10	14.60*	
	r ≤ 3	0.04	5.50	5.50	
Rice, Wheat, Spiked millet, Maize	r = 0	0.25	39.49*	68.26*	4
	r ≤ 1	0.12	17.73	28.78	
	r ≤ 2	0.05	7.69	11.05	
	r ≤ 3	0.02	3.37	3.37	

Note:
*(**) denotes rejection of the hypothesis at 5%(10%) significance level
© Order of VAR is determined by the adjusted LR Test

The long run equations based on first co-integrating vector normalized with respect to each of these cereals are presented in Annexture - 1. These normalizations are equivalent representations of the same co-integrating vector. The sign and magnitude of each variable changes according to normalizing variable. However, being derived from a single co-integrating vector, the relative magnitude between different variables is constant. We can derive economic interpretation from the relative strength of each variable in this co-

for wheat, rice and spiked millet are cointegrated and we want to test the significance of rice, the null hypothesis is $H_0 : \beta_{rice} = 0$: the market consists of wheat and spiked millet only. The alternate hypothesis is $H_1: \beta_{rice} \neq 0$, i.e., there is one common market for these three commodities. If the null hypothesis is rejected that implies that rice significantly contributes to the co-integration relation and that it is an important part of the common market.

integrating relationship.

Considering the equations for cereals in Annexture -1, the parameter for wheat was 3.65 times higher than that of spiked millet in equation (i). The parameter of rice was 5.96 times higher than that of spiked millet in equation (ii). This suggests that the interdependency between wheat-rice was relatively stronger than that of either wheat-spiked millet or rice-spiked millet. In equation (iii) the parameter of rice was 1.61 times higher than that of wheat suggesting that the interdependency of rice-spiked millet was greater than that of wheat-spiked millet. By putting these preferences together, we get an ordering of the relative strength of the variables suggested by our long run co-integration relationship. Combining the results of the above three, we get the combination of substitutes as rice-wheat ≥ rice-spiked millet ≥ wheat-spiked millet. Thus we conclude that there was price parity equilibrium in the cereals market excluding great millet, maize, barley and finger millet. In the long run the interdependence was evident in the order of rice, wheat and spiked millet.

4.2. Single Common Trend Among Pulses

Searching for a common market in the pulses, we considered five main pulses namely, Bengal gram, black gram, red gram, lentil and green gram. Out of these five pulses only lentil, green gram and Bengal gram were observed to belong to a single common market. Table 1.6 shows that only two co-integrating vectors were accepted by trace and maximum eigenvalue tests among lentil, green gram and Bengal gram. The remaining two pulses namely, red gram and black gram did not belong to the common market. Using exclusion tests to further verify the presence of a particular series in the co-integration relationship as in the case of cereals, the calculated CHSQ test statistics were 20.7 (green gram), 14.0 (lentil) and 14.1 (Bengal gram). The null hypothesis of exclusion was rejected at one-percent

Table 1.6. Johansen's Maximum Eigenvalue and Trace Test for the Number of Cointegrating Vectors in Pulses (Sample: 1990-04 to 2002-03)

Series in Logarithms	Null Hypothesis	Eigenvalue	Maximum Eigen (ξ_r)	Trace (η_r)	Order of VAR©
Lentil, Green gram	r = 0	0.16	25.24*	30.87*	2
	r ≤ 1	0.04	5.63	5.63	
Lentil, Green gram, Bengal gram	**r = 0**	**0.17**	**25.62***	**49.13***	**2**
	r ≤ 1	**0.13**	**19.34***	**23.51****	
	r ≤ 2	**0.03**	**4.17**	**4.17**	
Lentil, Green gram, Bengal gram, Red gram	r = 0	0.16	25.32**	51.13*	2
	r ≤ 1	0.13	19.28**	25.81	
	r ≤ 2	0.03	3.99	6.52	
	r ≤ 3	0.02	2.53	2.53	
Lentil, Green gram, Bengal gram, Black gram	r = 0	0.20	31.19*	65.24*	2
	r ≤ 1	0.14	21.61	34.04	
	r ≤ 2	0.06	8.19	12.43	
	r ≤ 2	0.03	4.24	4.24	

Note:
*(**) denotes rejection of the hypothesis at 5%(10%) significance level
© Order of VAR is determined by the adjusted LR Test

significance level leading to the conclusion that lentil, green gram and Bengal gram had a unique long run association.

The long run equations based on first co-integrating vector normalized with respect to each of these pulses are given in Annexture 1. In the next step we derive the order of preference for these pulses using the relative strength of each variable in the normalized equations. It is evident from these equations that the parameter of green gram was 9.16 times higher than that of Bengal gram in equation (i). The parameter of lentil was 3.18 times higher than that of Bengal gram in equation (ii). This implies that the association of green gram-lentil was stronger than that of either green gram-Bengal gram or lentil-Bengal gram. In equation (iii) the parameter of green gram was 2.84 times higher than that of lentil suggesting that the interdependency of green gram-Bengal gram was greater than that of lentil-Bengal gram. Combining the results of the above three, we get the desired preference of substitutes as green gram-lentil ≥ green gram-Bengal gram ≥ lentil-Bengal gram.

4.3. Single Common Trend Among Oilseeds

Among 9 major oilseeds only groundnut, mustard, sunflower and soybean were found to belong to a common market. It is evident from Table 1.7 that only 3 co-integrating vectors were accepted by both maximum eigenvalue and trace tests. As was mentioned in the previous section, these four oilseeds also constituted the major share (around 90 percent) of total oilseeds production. During 1999-00, the share of groundnut, soybean and rapeseed mustard in total 9 oilseeds' production was 25, 33 and 29 percent, respectively. However, sunflower had a meager share of 4 percent.

The results of exclusion tests further corroborate the presence of all the four oilseeds in the common market. The calculated CHSQ test statistics were 12.7, 18.8, 17.5 and 15.9 for soybean, sunflower, mustard and groundnut respectively, thus rejecting the null hypothesis of exclusion at one-percent significance level. The remaining 5 oilseeds namely, linseed, castor seed, cotton seed, niger seed and kardi seed having a production share of only 5 percent were not observed to have any common long run path with the above 4 major oilseeds. In the subsequent sections we would see the short run association among all these 9 oilseeds.

Based on the set of normalized equations of the first vector of co-integration (see Annexture-1), the order of preference for these four oilseeds is given in the following lines: The parameter for mustard was 1.31 times higher than that of sunflower in equation (i). The parameter of soybean was 1.07 times higher than that of sunflower in equation (ii). This implies that the association of mustard-soybean was stronger than that of either mustard-sunflower or soybean-sunflower. In equation (iii) the parameter of mustard was 1.24 times higher than that of soybean suggesting that the interdependency of mustard-sunflower was greater than that of soybean-sunflower. Combining the results of the above three, we get the combination of substitutes as mustard-soybean ≥ mustard-sunflower ≥ soybean-sunflower.

Similarly, we can find out the order of preference among the combinations of mustard, soybean and groundnut. The parameter of mustard in equation (iv) was 4.73 times higher than that of groundnut while parameter of soybean was 3.86 times higher than that of groundnut in equation (ii). This suggests that the interdependence between mustard-soybean was much higher than that of mustard-groundnut or soybean- groundnut. From equation (iii) it is discernible that parameter of mustard was 1.23 times higher than that of soybean thus concluding in the order of mustard-soybean ≥ mustard-groundnut ≥ soybean-groundnut.

Table 1.7. Johansen's Maximum Eigenvalue and Trace Test for the Number of Cointegrating Vectors in Oil-seeds (Sample: 1990-04 to 2002-03)

Series in Logarithms	Null Hypothesis	Eigenvalue	Maximum Eigen (ξ_r)	Trace (η_r)	Order of VAR©
Groundnut seed, Rape-mustard seed	r = 0	0.15	22.45*	30.99*	3
	r ≤ 1	0.06	8.54	8.54	
Groundnut seed, Rape-mustard seed, Sunflower seed	r = 0	017	25.84*	51.82*	1
	r ≤ 1	0.11	17.20**	25.98*	
	r ≤ 2	0.06	8.78	8.78	
Groundnut seed, Rape-mustard seed, Sunflower seed, Soybean seed	**r = 0**	**0.20**	**31.31***	**78.41***	**1**
	r ≤ 1	**0.15**	**23.72****	**47.10***	
	r ≤ 2	**0.11**	**16.55****	**23.37****	
	r ≤ 3	**0.05**	**6.82**	**6.82**	
Groundnut seed, Rape-mustard seed, Sunflower seed, Soybean seed, Lin seed	r = 0	0.30	51.59*	121.52*	1
	r ≤ 1	0.20	32.18*	69.93*	
	r ≤ 2	0.14	21.15	37.75	
	r ≤ 3	0.07	9.92	16.59	
	r ≤ 4	0.05	6.68	6.68	
Groundnut seed, Rape-mustard seed, Sunflower seed, Soybean seed, Castor seed	r = 0	0.26	43.95*	101.91*	1
	r ≤ 1	0.15	23.96	57.96	
	r ≤ 2	0.13	20.51	34.01	
	r ≤ 3	0.05	7.24	13.50	
	r ≤ 4	0.04	6.26	6.26	
Groundnut seed, Rape-mustard seed, Sunflower seed, Soybean seed, Cotton seed	r = 0	0.21	33.07**	83.91*	1
	r ≤ 1	0.16	25.60**	50.84**	
	r ≤ 2	0.08	12.57	25.24	
	r ≤ 3	0.05	7.06	12.67	
	r ≤ 4	0.04	5.61	5.61	
Groundnut seed, Rape-mustard seed, Sunflower seed, Soybean seed, Kardi seed	r = 0	0.27	44.40*	104.63*	1
	r ≤ 1	0.16	25.12	60.23*	
	r ≤ 2	0.13	19.95	35.11	
	r ≤ 3	0.06	9.38	15.16	
	r ≤ 4	0.04	5.79	5.79	
Groundnut seed, Rape-mustard seed, Sunflower seed, Soybean seed, Niger seed	r = 0	0.26	42.79*	95.79*	3
	r ≤ 1	0.16	24.29	53.01	
	r ≤ 2	0.13	18.98	28.71	
	r ≤ 3	0.04	5.48	9.73	
	r ≤ 4	0.03	4.25	4.25	

Note:
*(**) denotes rejection of the hypothesis at 5%(10%) significance level
© Order of VAR is determined by the adjusted LR Test

Finally, from equation (ii) or (iv) we could calculate that the parameter of sunflower was 3.62 times higher than that of groundnut suggesting that the association between mustard-sunflower and soybean-sunflower was greater than that of mustard-groundnut and soybean-goundnut. Now putting these preferences together we get an ordering of the relative strength of the variables suggested by our long run co-integration relationship as: mustard-soybean ≥ mustard-sunflower ≥ soybean-sunflower ≥ mustard-groundnut ≥ soybean-groundnut ≥ sunflower-groundnut.

4.4. Single Common Trend Among Edible oils

The major edible oils we selected for this study were groundnut, rape-seed-mustard, coconut, imported edible, hydro-generated-*vanaspati*, cotton-seed and rice-bran oils. Among these seven edible oils, only the three major ones, namely groundnut, rape-seed-mustard and coconut were found having a long run association. It is seen from Table 1.8 that only two co-integrating vectors were found by eigenvalue and trace tests. Thus, cotton-seed, *vanaspati*, imported edible and rice bran oils were observed not to be associated with the above three, i.e., groundnut, rape-mustard and coconut oil.

Table 1.8. Johansen's Maximum Eigenvalue and Trace Test for the Number of Cointegrating Vectors in Edible oils (Sample: 1990-04 to 2002-03)

Series in Logarithms	Null Hypothesis	Eigenvalue	Maximum Eigen (ξ_r)	Trace (η_r)	Order of VAR©
Groundnut oil,	r = 0	0.13	20.13*	28.06*	3
Rape-mustard oil	r ≤ 1	0.05	7.93	7.93	
Groundnut oil,	**r = 0**	**013**	**19.56****	**35.45***	**1**
Rape-mustard oil,	**r ≤ 1**	**0.09**	**13.40****	**15.89****	
Coconut oil	**r ≤ 2**	**0.02**	**2.49**	**2.49**	
Groundnut oil,	r = 0	0.17	26.94**	46.90**	1
Rape-mustard oil,	r ≤ 1	0.10	14.41	19.96	
Coconut oil,	r ≤ 2	0.03	4.36	5.56	
Imported Edible oil	r ≤ 3	0.01	1.20	1.20	
Groundnut oil,	r = 0	0.19	30.99*	63.90*	1
Rape-mustard oil,	r ≤ 1	0.15	22.61*	32.91*	
Coconut oil,	r ≤ 2	0.06	9.44	10.29	
Rice-bran oil,	r ≤ 3	0.01	0.85	0.85	
Groundnut oil,	r = 0	0.23	37.59*	76.00*	1
Rape-mustard oil,	r ≤ 1	0.16	24.23**	38.41**	
Coconut oil,	r ≤ 2	0.08	11.45	14.18	
Hydro-*Vanaspati* oil	r ≤ 3	0.02	2.73	2.73	
Groundnut oil,	r = 0	0.21	33.75*	77.35*	2
Rape-mustard oil,	r ≤ 1	0.13	19.68	43.61*	
Coconut oil,	r ≤ 2	0.10	15.16	23.93**	
Cotton-seed oil,	r ≤ 3	0.06	8.77	8.77	

Note:
*(**) denotes rejection of the hypothesis at 5%(10%) significance level
© Order of VAR is determined by the adjusted LR Test

The CHSQ (exclusion) test further confirmed the presence of these three edible oils in the common market. The hypothesis was rejected at one percent significance level in all the three edible oils as the estimated test statistics were 7.6 (coconut oil), 11.1 (mustard oil) and 10.7 (groundnut oil). The order of preference drawn from the set of normalized equations (as given in Annexture-1) of the first vector stood as – Mustard-coconut > mustard-groundnut > coconut-groundnut.

5. THE ERROR-CORRECTION MODEL

An explanation for the long run interdependence among the variables lies in the short run dynamics. One would like to know the intertwined relationship in the short run giving way to a long run association. The relationship was estimated by error-correction model (Engle and Granger 1987). The advantage of error-correction model is that it allows for the short run dynamics as well as an assessment for the degree of convergence towards the long run relation as shown by the co-integration. The model is formulated by including the respective variables in their first difference, their lagged values and the lagged residuals from the co-integration equations.

5.1. Cereals

Before starting the discussion, it is essential to note that the coarse grains namely, great millet, barley and finger millet, which were observed not belonging to the common market in the co-integration analysis have been included in the short run analysis of error-correction. Further, to check short run association of maize with the other cereals, the former was included in the ECM equations. However, maize was included in levels as this variable was observed as stationary, the other variables namely, great millet, barley and finger millet were included in their first difference as latter were all not stationary variables. The results for the cereals show that the estimates of the error correction coefficients were highly significant and their signs were negative (Table 1.9). This implies that the short run price movements along the long run equilibrium path were stable. The coefficients of the error correction terms indicate the speed of convergence to the long run growth path as a result of a shock in their own prices. The estimated coefficients show that the speed of adjustment to a shock in their own prices was rather slow in the case of rice as compared to wheat and spiked millet. Any shock in prices took about 3-4 weeks adjustment period to get back to the long run path in the case of rice and 2-3 weeks period in the case of wheat and spiked millet in a months' time period.

The coefficients of the own lagged prices and prices of the substitutes reveal that rice price was affected by wheat, with a two month lag, while the impact of its own price took place with one month delay. With respect to coarse grains, although barley and finger millet did not share a common path with rice in the long run, they were significant substitutes in the short run (see Table 1.9). Wheat price was affected by its own lagged price and also by the lagged prices of other two cereals, i.e., rice with a lag of two months and spiked millet with a lag of one month. The movements in prices of great millet and barley also caused variation in wheat prices in the short run, though in the long run they did not share a common path. In the case of spiked millet, there was a significant impact of change in its own price and the price of wheat with a month lag while finger millet and maize affected its price only in the short run.

Table: 1.9. Reduced Form VECM for Cereals (Period 1990-04 to 2002-03)

	ΔLog Rice		ΔLog Wheat		ΔLog Spiked millet	
	Coefficient	‘t’ Value	Coefficient	‘t’ Value	Coefficient	‘t’ Value
ECM	-0.12	-(2.0)	-0.14	-(2.3)	-0.20	-(4.0)
Constant	-0.00	-(0.7)	0.00	(0.0)	0.00	(0.8)
ΔLog Rice $_{-1}$	0.24	(2.5)	-0.16	-(1.0)	-0.35	-(1.4)
ΔLog Rice $_{-2}$	0.20	(2.0)	-0.28	-(1.7)	0.02	(0.1)
ΔLog Rice $_{-3}$	-0.01	-(0.1)	-0.02	-(0.1)	-0.39	-(1.5)
ΔLog Rice $_{-4}$	0.10	(1.0)	0.08	(0.5)	-0.27	-(1.0)
ΔLog Rice $_{-5}$	-0.11	-(1.1)	0.20	(1.2)	-0.17	-(0.6)
ΔLog Wheat $_{-1}$	-0.03	-(0.6)	0.32	(3.7)	0.24	(1.8)
ΔLog Wheat $_{-2}$	-0.08	-(1.5)	-0.10	-(1.1)	0.27	(1.9)
ΔLog Wheat $_{-3}$	0.01	(0.3)	-0.05	-(0.5)	-0.01	-(0.1)
ΔLog Wheat $_{-4}$	-0.06	-(1.3)	-0.05	-(0.6)	0.41	(3.1)
ΔLog Wheat $_{-5}$	-0.02	-(0.4)	0.02	(0.2)	0.06	(0.5)
ΔLog Spiked millet $_{-1}$	0.00	(0.0)	0.08	(1.4)	0.27	(3.2)
ΔLog Spiked millet $_{-2}$	-0.02	-(0.5)	0.02	(0.4)	-0.17	-(1.9)
ΔLog Spiked millet $_{-3}$	0.04	(1.1)	-0.01	-(0.1)	0.25	(2.9)
ΔLog Spiked millet $_{-4}$	0.00	-(0.1)	-0.10	-(1.8)	0.11	(1.3)
ΔLog Spiked millet $_{-5}$	-0.01	-(0.4)	-0.11	-(2.0)	0.01	(0.1)
ΔLog Great millet	-0.02	-(0.5)	0.11	(1.7)	0.21	(2.1)
ΔLog Barley	0.07	(2.4)	0.28	(5.7)	0.06	(0.7)
ΔLog Finger millet	0.16	(2.9)	-0.02	-(0.2)	0.41	(2.9)
Log Maize	0.01	(0.7)	0.01	(0.4)	0.10	(2.0)
R^2	0.30		0.65		0.51	
R^{-2}	0.17		0.59		0.43	
Log Likelihood	410.4		340.1		276.8	
D-W	1.96		1.95		1.89	
AIC	-5.63		-4.61		-3.69	
LM(12)	0.69		1.86**		0.99	
ARCH(12)	0.57		1.27		0.50	
Jarque Bera	27.33*		2.93		0.51	
Reset (Ramsay)	0.32		0.85		0.29	
Chow Breakpoint test	1.39		1.14		1.02	

5.2. Pulses

The coefficients of error-correction were highly significant with a desired negative sign in all the three pulses namely, lentil, green gram and Bengal gram. The implication is that these price series were stable in the long run and any deviation rooted in their prices by any external shock was adjusted over time. However, the pace of adjustment depends on the magnitude of the coefficients. It is evident from Table 10.1 that the adjustment period in pulses was higher as compared to cereals. The coefficient of ECM was less, 0.1 in the case of lentil and Bengal gram, while it was 0.18 in the case of green gram. It implies that the adjustment period to any price shock during one month's time period would be 3-4 weeks or even more in the case of pulses.

The coefficients of reduced form VECM indicate that lentil price was affected by two months lag price of green gram and its own lagged price of one month. Movements in green gram and Bengal gram prices, on the other hand, were determined by changes in their own prices alone. However, red gram and black gram, which were not sharing any common market with these pulses in the long run, had a fairly significant association with all the three pulses in the short run (see Table 1.10).

Table: 1.10. Reduced Form VECM for Pulses (Period 1990-04 to 2002-03)

	ΔLog Lentil		ΔLog Green gram		ΔLog Bengal gram	
	Coefficient	't' Value	Coefficient	't' Value	Coefficient	't' Value
ECM	-0.08	-(3.1)	-0.18	-(4.7)	-0.09	-(3.8)
Constant	0.01	(1.0)	-0.02	-(3.5)	-0.02	-(2.0)
ΔLog Lentil $_{-1}$	0.41	(5.2)	-0.07	-(1.2)	-0.03	-(0.3)
ΔLog Lentil $_{-2}$	-0.08	-(1.0)	-0.04	-(0.7)	0.03	(0.3)
ΔLog Green gram $_{-1}$	0.06	(0.6)	0.40	(5.0)	-0.11	-(0.9)
ΔLog Green gram $_{-2}$	-0.20	-(1.7)	0.09	(1.0)	-0.12	-(0.9)
ΔLog Bengal gram $_{-1}$	-0.06	-(0.9)	-0.01	-(0.2)	0.60	(7.4)
ΔLog Bengal gram $_{-2}$	0.05	(0.7)	0.03	(0.5)	-0.06	-(0.7)
@Trend	0.00	-(0.8)	0.00	(3.8)	0.00	(2.5)
ΔLog Red gram	0.30	(3.7)	0.09	(1.4)	0.18	(2.0)
ΔLog Black gram	0.14	(1.8)	0.15	(2.5)	0.14	(1.6)
R^2	0.37		0.33		0.44	
R^{-2}	0.31		0.27		0.39	
Log Likelihood	283.2		320.8		265.6	
D-W	1.99		1.90		1.99	
AIC	-3.85		-4.38		-3.60	
LM(12)	1.92**		0.81		0.99	
ARCH(12)	1.56		0.82		0.91	
Jarque Bera	5.92		12.7*		11.4*	
Reset (Ramsay)	0.45		3.03		0.59	
Chow Breakpoint	0.93		1.82		1.38	

5.3. Oilseeds

The estimates of the error correction coefficients in the case of oilseeds were significant for groundnut, soybean and rape-seed-mustard, but insignificant in the case of sunflower (see Table 1.11). Thus, the former three oilseeds had a stable long run path while the movements in the latter case were random in the long run. The speed of adjustment towards long run equilibrium was fast, around 2-3 weeks in the case of groundnut seeds. In the case of soybean and rape-seed-mustard, the adjustment period was 3-4 weeks while in the case of sunflower, error correction was not taking place. The case of sunflower implies that prices once displaced from equilibrium did not have a tendency to come back to the previous equilibrium level.

The estimated coefficients of own prices and prices of substitutes for oilseeds reveal that in the common market (i.e., groundnut, rape-seed-mustard, sunflower and soybean) prices were not affected by the substitutes in the short run. Further, soybean and sunflower prices were not affected by their own prices as well (see Table 1.11). The prices of these four oilseeds in the short run were rather determined by the movements in prices of other five oilseeds, which were not part of the common market namely, linseed, castorseed, cottonseed, nigerseed and kardiseed.

Table: 1.11. Reduced Form VECM for Oilseeds (Period 1990-04 to 2002-03)

	ΔLog Groundnut seed		ΔLog Rape-Mustard seed		ΔLog Sunflower seed		ΔLog Soybean seed	
	Coefficient	't' Value	Coefficient	't' Value	Coefficient	't' Value	Coefficient	't' Value
ECM	-0.25	-(4.3)	-0.06	-(2.0)	-0.07	-(1.2)	-0.12	-(4.2)
Constant	0.03	(2.7)	0.01	(0.9)	0.06	(2.9)	0.02	(1.3)
ΔLog Ground $_{-1}$	0.20	(2.1)	-0.09	-(0.9)	-0.10	-(0.5)	-0.01	-(0.1)
ΔLog Mustard $_{-1}$	0.00	(0.0)	0.22	(2.7)	-0.08	-(0.5)	0.08	(0.8)
ΔLog Sunflwr $_{-1}$	0.04	(0.8)	0.02	(0.5)	-0.10	-(1.0)	0.07	(1.1)
ΔLog Soybean $_{-1}$	-0.01	-(0.2)	0.07	(1.0)	-0.11	-(0.8)	0.07	(0.8)
Time Trend	0.00	-(1.7)	0.00	-(1.6)	-0.00	-(2.5)	-0.00	-(2.5)
ΔLog Linseed	0.09	(1.1)	0.46	(5.9)	0.16	(1.0)	0.19	(1.9)
ΔLog Castorseed	-0.02	-(0.4)	0.05	(0.8)	-0.10	-(0.9)	-0.08	-(1.2)
ΔLog Cottonseed	0.29	(3.7)	0.23	(2.8)	0.53	(3.3)	0.03	(0.3)
ΔLog Nigerseed	0.05	(0.9)	-0.01	-(0.2)	-0.10	-(0.9)	0.11	(1.5)
ΔLog Kardiseed	0.01	(0.1)	0.12	(1.9)	0.34	(2.7)	-0.08	-(1.0)
R^2	0.36		0.50		0.25		0.26	
R^{-2}	0.30		0.45		0.17		0.19	
Log Likelihood	302.0		300.4		201.8		266.1	
D-W	1.99		1.85		2.03		2.02	
AIC	-4.06		-4.03		-2.64		-3.55	
LM(12)	1.09		1.03		1.57		0.62	
ARCH(12)	0.84		0.98		1.43		0.97	
Jarque Bera	9.51*		5.66		2.43		21.6*	
Reset (Ramsay)	0.00		1.35		1.04		1.63	
Chow Breakpoint	1.72		1.80**		0.41		1.96**	

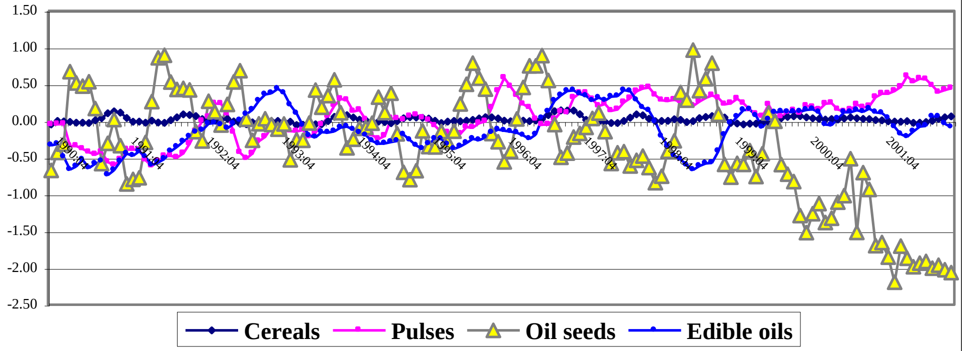
5.4. Edible Oils

In sharp contrast to the results obtained in the case of oilseeds, coefficients of the error correction terms for edible oils were highly significant. The speed of adjustment of a shock towards long run equilibrium was however, slow, about four weeks in a month's time period. This was reflected by the coefficient of error-correction term, -0.04 for coconut oil, -0.08 for groundnut oil and -0.09 for mustard oil (see Table 1.12). The impact of own prices and prices of substitutes exhibited that the edible oils in the common market (groundnut, mustard and coconut) were affected by their own prices alone. As was observed in the case of oilseeds, the prices of these three edible oils in the long run were determined by the movements in prices of other four edible oils, which were not part of the common market, namely, imported edible oil, rice-bran oil, hydro-generated *vanaspati* oil and cotton-seed oil. Finally, given the fact that the error-correction equations were estimated in first difference form, the values of R^2 were reasonably low, ranging between 0.30 and 0.70 in the above four cases, i.e., cereals, pulses, oilseeds and edible oils. The diagnostic tests presented in the tables – LM, ARCH, normality, specification and stability- pointed out the right specifications of the equations estimated.

Table: 1.12. Reduced Form VECM for Edible oils (Period 1990-04 to 2002-03)

	ΔLog Groundnut oil		ΔLog Mustard oil		ΔLog Coconut oil	
	Coefficient	't' Value	Coefficient	't' Value	Coefficient	't' Value
ECM	-0.08	-(2.4)	-0.09	-(2.9)	-0.04	-(3.2)
Constant	0.00	(0.6)	0.00	-(0.8)	-0.01	-(1.8)
ΔLog $Goil_{-1}$	0.28	(3.5)	0.05	(0.6)	-0.07	-(0.7)
ΔLog $Rmoil_{-1}$	-0.01	-(0.2)	0.51	(7.2)	0.09	(1.1)
ΔLog $Cocoil_{-1}$	-0.07	-(1.1)	0.05	(0.7)	0.37	(4.5)
ΔLog Ieoil	-0.13	-(2.0)	-0.20	-(3.2)	-0.06	-(0.8)
ΔLog Rboil	0.17	(4.1)	0.16	(3.8)	0.03	(0.7)
ΔLog Hvoil	0.19	(1.7)	0.13	(1.1)	0.06	(0.4)
ΔLog Cseedoil	0.23	(3.2)	0.23	(3.3)	0.04	(0.5)
R^2	0.39		0.55		0.28	
R^{-2}	0.35		0.52		0.23	
Log Likelihood	298.5		299.0		275.3	
D-W	1.94		1.87		2.11	
AIC	-4.06		-4.07		-3.74	
LM(12)	1.01		1.13		1.13	
ARCH(12)	0.69		0.84		0.54	
Jarque Bera	37.8*		2.04		47.5*	
Reset (Ramsay)	1.42		0.37		1.88	

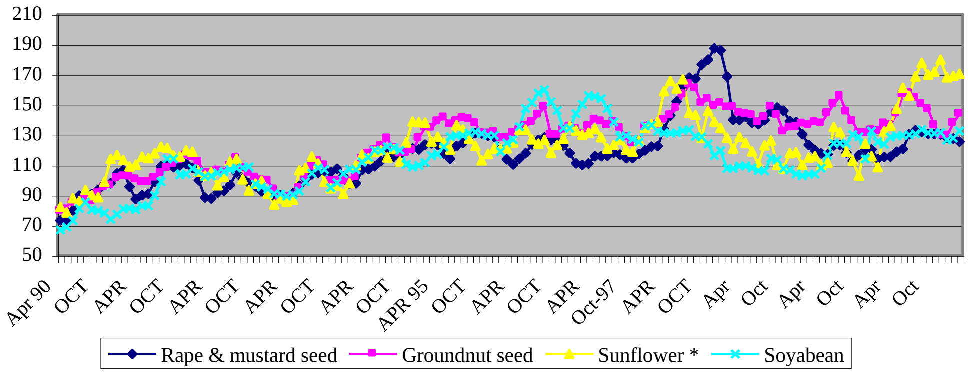
Figure 1.1: Long Term Adjustment Path



The results of co-integration and error-correction are summarized in Figure 1.1. The figure presents a comparative picture of long run path of price adjustments for cereals, pulses, oilseeds and edible oils. It is clearly evident from the plots that diversions across the long-run path were highest in the case of oilseeds. It was seen in the previous section that the coefficients of error-correction in oilseed crops were either insignificant or very small except that of groundnut. As a result, the magnitude of diversions across the long run path was high in oilseeds. Further, it is apparent from Figure 1.1 that in the late 1990's, prices were drifting away from the long run equilibrium path. The drift in prices might have occurred due to the exceptional increase in prices of oilseeds during the year 1998-99. The oilseed market was severely hit during 1998-99 due to loss of human lives because of dropsy disease that broke out in many states in India as a result of adulterated mustard oil. A majority of state governments banned the sale of loose mustard oil, which caused disturbance in the oilseeds market[10]. Nonetheless, the drift is not visible in the case of edible oils probably because of the presence of imported edible oils, which partially evened out the rise in prices of mustard and other edible oils. The diversions were least for cereals and to some extent for pulses, evidently because no such disturbance happened in their case. Moreover, there is an effective procurement and minimum support price policy adopted by the Government of India, absorbing price shocks in the case of cereals' while oilseeds and edible oils depend entirely on the market situation.

[10] However, the drift in prices was only an aberration and was not a structural break as it occurred for a very small period and the prices returned to their normal level within a short span of time. Moreover, the drift was most acute only in the case of mustard seed (Figure 1.2). The ECM equations were tested for structural break by employing the CUSUM squared test as well as Chow's break point test (CUSUM graphs are not presented in the paper while they are available with the author). Even in the case of mustard seed, it was observed that CUSUM graph did not display any structural break.

Figure 1.2: Price indices of oilseeds in India (1993-94 = 100)



6. CONCLUDING REMARKS

Price volatility in agricultural products affects both producers and consumers. Enormously high growth in the prices of primary commodities spills over to other sectors ultimately leading to high inflation in the economy. For the proper understanding of excessive variations in prices of agricultural commodities it is essential to know the linkages that exist between different commodity complexes. It is an accepted fact that despite varying food habits, consumers switch their consumption patterns to close substitutes in response to an increase or decrease in the price of a particular commodity. To the extent they do so, any shortage in one commodity in the market is likely to increase the demand for another, which will be reflected in the increase in the price of that particular substitute. Therefore, it becomes important to know how movements in the prices of one substitute are transmitted to another. An understanding of transmission of price signals from one commodity to another and their degree of association is central to the implementation of price stabilization of commodities. The main objective of this paper is to analyze the nature of price inter-linkages among agricultural commodities in India. To work out the price linkages the commodity complexes considered in this paper are cereals, pulses, oilseeds and edible oils.

The main conclusions emerged from the co-integration and error-correction analysis are briefed in the following lines: In the case of cereals, a unique co-integration relationship was verified among wheat, rice and spiked millet by the trace and maximum eigenvalue tests and was further confirmed by the exclusion tests. The other coarse grains namely, great millet, maize, barley and finger millet were not found as belonging to the common market of cereals in the long run. In the short run however, barley and finger millet were significant substitutes for rice while, wheat price was affected by great millet and barley and variations in spiked millet price were partially explained by finger millet and maize.

The estimates of error correction coefficients were highly significant with negative signs indicating stable movements in cereal prices along the long run path. Any shock in prices took about 3-4 weeks adjustment period to get back to the equilibrium in the case of rice and 2-3 weeks period in the case of wheat and spiked millet in a month’s time period. In the long run, the interdependence among cereal prices was evident in the order of rice, wheat and spiked millet and the combination of substitutes were observed as rice-wheat ≥ rice-spiked millet ≥ wheat-spiked millet.

Among pulses, only lentil, green gram and Bengal gram had a long run co-integration relation and thus formed a single common market of pulses. The other two pulses, namely, red gram and black gram did not belong to the common market. Nonetheless, although the latter two pulses did not share any common market with former three in the long run, they had a fairly significant association with the above three pulses in the short run. The coefficients of error-correction were highly significant with a desired negative sign indicating stable price movements. However, the period of adjustment in pulses was higher compared to cereals (about 3-4 weeks or even more). The order of preference for substitutes was derived as green gram-lentil ≥ green gram-Bengal gram ≥ lentil-Bengal gram.

Among nine major oilseeds only groundnut, mustard, sunflower and soybean belonged to a common market as only three co-integrating vectors were accepted by both maximum eigenvalue and trace tests. The remaining five oilseeds, namely, linseed, castor seed, cotton seed, niger seed and kardi seed with a production share of only 5 percent were not observed sharing any common market with the above four oilseeds, although in the short run they governed the price movements of the above four oilseeds. The estimates of the error correction coefficients in the case of oilseeds were significant for groundnut, soybean and rape-seed-mustard, but insignificant in the case of sunflower. Thus, the former three oilseeds had a stable long run path while the movements in the latter case were random and no error-correction was taking place in this case. The ordering of the relative strength of oilseeds was found as, mustard-soybean ≥ mustard-sunflower ≥ soybean-sunflower ≥ mustard-groundnut ≥ soybean-groundnut ≥ sunflower-groundnut.

In the case of edible oils, only three major ones namely, groundnut, rape-seed-mustard and coconut were found having a long run association. The other four edibles, namely, cotton-seed, *vanaspati*, imported edible and rice bran oils were not associated with the above three in the long run. In the short run however, similar to the case of oilseeds, the prices of these three edible oils were determined by the movements in prices of four edible oils, which were not part of the common market. Unlike oilseeds, coefficients of the error correction terms for edible oils were highly significant. However, the speed of adjustment of a shock towards long run equilibrium was slow, about four weeks in a month’s time period. The order of preference drawn from the set of normalized equations of the first vector stood as – Mustard-coconut > mustard-groundnut > coconut-groundnut.

Finally, summing up the results of above discussion it was observed that the diversions across the long-run path were highest in the case of oilseeds. Further, in the late 1990’s, prices of oilseeds were drifting away from the long run equilibrium path possibly because of disturbance in the oilseeds market caused by the dropsy disease in 1998-99. Nonetheless, the drift was not visible in the case of edible oils probably because of the presence of imported edible oils, which partially evened out the rise in prices of mustard and other edible oils. The diversions across long run path were least for cereals, evidently because of the cushioning effect of measures taken by the Government of India such as procurement and minimum support price policy.

Annexture – 1
Normalized Coefficients of Co-integration Equations

Cereals:

Log Rice = 0.62 * Log Wheat + 0.17 * Log Spiked millet (i)
Log Wheat = 1.61 * Log Rice - 0.27 * Log Spiked millet (ii)
Log Spiked millet = 6.02 * Log Rice - 3.73 * Log Wheat (iii)

Pulses:

Log Lentil = 2.84 * Log Green gram + 0.31 * Log Bengal gram (i)
Log Green gram = 0.35 * Log Lentil - 0.11 * Log Bengal gram (ii)
Log Bengal gram = 3.24 * Log Lentil - 9.21 * Log Green gram (iii)

Oilseeds

Log Groundnut = 4.76 * Log Mustard – 3.63 * Log Sunflower + 3.86 Log Soybean (i)
Log Mustard = 0.21 * Log G-nut + 0.76 * Log Sunflower - 0.81 Log Soybean (ii)
Log Sunflower = -0.28 * Log G-nut + 1.31 * Log Mustard + 1.06 Log Soybean (iii)
Log Soybean = 0.26 * Log G-nut - 1.23 * Log Mustard + 0.94 Log Sunflower (iv)

Edible Oils

Log Groundnut = -1.24 * Log Mustard + 1.09 * Log Coconut (i)
Log Mustard = -0.81 * Log Groundnut + 0.89 * Log Coconut (ii)
Log Coconut = 0.91 * Log Groundnut + 1.13 * Log Mustard (iii)

Annex Table 1. Availability of cereals, pulses, oilseeds and edible oils in India (Quantity in 000' tones)

Year	Net production	Net imports	Change in stocks	Net availability	Availability as a percentage of production
Cereals					
1991	141859	-574	-4392	145677	102.69
1996	147092	-3562	-8534	152064	103.38
1997	162043	-576	-1780	163247	100.74
1998	156869	-2844	6142	147883	94.27
1999	165113	-1513	7505	156095	94.54
2000	171084	-1399	13879	155806	91.07
Pulses					
1991	12482	433	0	12915	103.47
1996	10771	482	0	11253	104.47
1997	12464	530	0	12994	104.25
1998	11357	337	0	11694	102.97
1999	13043	245	0	13288	101.88
2000	11681	29	0	11710	100.25
Oilseeds					
1991	18609	-112	0	18497	99.40
1996	22105	-205	0	21900	99.07
1997	24385	-258	0	24127	98.94
1998	21325	-393	0	20932	98.16
1999	24748	-169	0	24579	99.32
2000	20872	-280	0	20592	98.66
Edible oils					
1991	4586	523	0	5109	111.40
1996	5127	712	0	5839	113.88
1997	5684	926	0	6610	116.29
1998	4626	905	0	5531	119.57
1999	5397	2107	0	7504	139.04
2000	4546	3536	0	8082	177.77

Source: Bulletin on Food Statistics – Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, various years

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