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Co-integration between Prices of Mango in Lucknow Market and International Market

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Abstract
Government of India is making all efforts to increase integration among markets of the country. In this direction e-National Agriculture Market (e-NAM) has been implemented. The e-NAM trading mechanism proposes to regulate all the wholesale market or Agricultural Produce Market Committees (APMCs) under one electronic platform throughout the country. In respect of this the study was conducted to test the extent of market co-integration of price of mango among major market of Uttar Pradesh and its international prices using Johansen Granger Causality Tests and also captures the speed of adjustment to deviations in long run equilibrium in mango markets by using Vector Error Correction Model. In this study, the export prices were considered to be the international prices and secondary data pertains to the year 1993 to 2015 of international price and Lucknow market price was collected from Food and Agricultural Organisation and Agricultural Produce Market Committee Lucknow, respectively. The results showed rejection of the null hypothesis that there was no co-integrated vector (None) and accepted the alternative hypothesis that there is at most 1 co-integrated vector in both trace statistics and maximum eigen value statistics as having no intercept in co-integrating equation (CE) and no intercept in vector auto regression (VAR). It shows long run association between Lucknow market price and International market price used in current study. Vector error correction model showed the Lucknow market price of mango in India will converge towards long run equilibrium after taking 31 per cent monthly adjustments, but in International market it as very low and converge towards long run equilibrium after taking 14 per cent monthly adjustments. The direction of the relationship among price series and market is equally important for which Granger Causality tests were performed. It shows the unidirectional causality revealed in the International market which lead to the prices in Lucknow market.

Keywords: Co-integration, Price, Causality, Error correction and Market

Introduction
The e- trading platform for the National Agricultural Market was launched by Prime Minister of India to get the more and more benefit to the farmers of the country via transparency in marketing of agricultural commodities. NAM helps in facing the challenges by creating a unified market through online trading platform, both, at State and National level and promotes uniformity, streamlining of procedures across the integrated markets, removes information asymmetry between buyers and sellers and promotes real time price discovery, based on actual demand and supply, promotes transparency in auction process, and access to a nationwide market for the farmer, with prices commensurate with quality of his produce and online payment and availability of better quality produce and at more reasonable prices to the consumer (Press Information Bureau, MoA, GOI, 2016) [11].

The study regarding co-integration between the markets are necessary to test whether the Law of One Price (LOOP) holds good in all these markets and to know the effect of other fruits prices on mango prices for the transaction behavior of buyers towards seasonal fruit mango. It can suggest to the producer's as to where, when and how much to sell, which in turn will have bearing on their production strategies and hence, resource allocation. In an integrated market, price of a commodity is responsive to price changes of the same quality products in other markets, as such price differences for a particular variety of product in different markets of the area as a rule should not exceed the cost involved in the transportation and handling of the produce. In this context, the present study was taken up with the objectives to examine the co-integration between prices of Mango in the one of the largest producing state market and international market.

Materials and methods
Lucknow market was selected purposively on the basis of highest arrivals of mango. In this study, the export prices were considered to be the international prices. The export price was not only dependent on internal policy rather it also depends on international trade.

So, due to unavailability of data from the mango market of any other country; export price was considered to be the international price for mango. The secondary data of international price and Lucknow market price was collected from Food and Agricultural Organisation and Agricultural Produce Market Committee Lucknow, respectively. Monthly data of mango price pertains to the year 1993 to 2015. The tools used for analysis were Johansen's co-integration test, Engel Granger Error Correction Model and Granger Causality Test. Analysis of collected data was done using software Eviews-7.

Co-integration: The concept of co-integration and the methods for estimating the co-integrated relation (Engle and Granger, 1987) [2] provides a framework for estimating and testing the long run equilibrium relationships between the non-stationary integrated variables. If p1t and p2t are the prices in two spatially separated markets having different levels of the supply chain, if they are integrated of the same order, say I (d) and there is at least one linear combination of these market prices are stationary, then they are said to be co-integrated.
It can be expressed as below,

$$P_{1t} = \beta_0 + \beta P_{2t} + u_t \quad \text{(i)}$$

Where, β is the co-integrating coefficient and the equation (i) is referred to be as the co-integrating regression model. Before going to co-integration estimation procedure it is necessary to check for the stationarity of variables. Testing for co-integration implies testing for the long-run relationship between variables. There are number of co-integration tests, namely the Engle-Granger method commonly known as the two-step estimation procedure developed by Engle and Granger (1987) [2] and the Johansen's procedure commonly known as a Full Information Maximum Likelihood method developed by Johansen (1988) [5].

a. The Engle-Granger method: Engle and Granger developed this crucial technique in 1987. This technique entails co-integrated variables which are discussed at length including a proof of Granger's representation theorem, which connects the moving average, the autoregressive, and the error correcting representation for co-integrated systems.

Once the hypothesis of the unit root test for each variable is rejected, we estimate the long-run equilibrium relationship in the form of an OLS regression line.

$$P_{1t} = \beta_0 + \beta_1 P_{2t} + \varepsilon_t \quad \text{(ii)}$$

Where β_0 is the intercept, β_1 is the slope, and ε_t is the error term.
In order to determine if variables co-integrate, we test for unit roots on the residual sequence using the ADF test. The residual sequence, denoted by ε_t is a series of estimated values of the deviation from the long-run relationship. They are estimated from

$$\varepsilon_t = P_{1t} - \hat{P}_{1t} \quad \text{(iii)}$$

Where, $\hat{P}_{1t}$ are values from the predicted equation.
Testing for unit roots on residuals aims at determining whether these deviations are stationary or not. If they are stationary, then the series co-integrate. If the residuals are not stationary, there is no co-integration. The ADF test is performed on the following model

$$\Delta\hat{\varepsilon}_t = a_1\hat{\varepsilon}_{t-1} + \varepsilon_t \quad \text{(iv)}$$

Where, $\Delta\hat{\varepsilon}_t$ are the estimated first differenced residuals, $\hat{\varepsilon}_{t-1}$ are the estimated lagged residuals, a_1 is the parameter of interest representing the slope of the line and ε_t are errors obtained in fitting both differenced residuals.
Since the ε_t sequences are residuals from a regression equation, there is no need to include the intercept term in equation above. To test the hypothesis on a_1 to determine whether the residuals are stationary, we follow the steps as mentioned above in ADF test. The rejection of H_0 implies that residuals are stationary. This further implies that the variables under study are co-integrated.

b. Johansen's procedure: Johansen's co-integration test relies on maximum likelihood method. This procedure is based on the relationship between the rank of a matrix and its characteristic roots. Johansen derived the maximum likelihood estimation using sequential tests for determining the number of co-integrating vectors. Johansen suggested two test statistics to test the null hypothesis that there are at most 'r' co-integrating vectors. This can equivalently be stated as the rank of the coefficient matrix (∏), is at most 'r' for r=0, 1, 2, 3…n-1. The two test statistics are based on the trace and maximum Eigen values, respectively.

$$\Delta P_t = \alpha + \beta_t + (p-1)P_{t-1} + \theta_1\Delta P_{t-1} + \dots\dots\dots + \theta_{k-1}\Delta P_{t-k+1} + W_t \quad \text{(v)}$$
$$\lambda_{trace} = -T\sum_{i=r+1}^{n}\ln(1-\lambda_i) \quad \text{(vi)}$$
$$\lambda_{max} = T\ln(1-\lambda_{r-1}) \quad \text{(vii)}$$

In testing for efficiency of two spatially separated markets (which is the necessary condition for market integration) the null hypothesis should be tested for r=0 and r=1. If r=0 cannot be rejected, it can be concluded that there is no co-integration. On the other hand, if r=0 is rejected and r=1 cannot be rejected then it can be concluded that there is a co-integrating relationship. Co-integration implies that there exist a co-integrating vector **β**. The hypothesis in market efficiency can be tested by imposing restrictions on the co-integrating vector β. Then the standard likelihood ratio test can be applied in this case. Specifically, the test statistics can be expressed by the canonical correlations as Johansen (1988) [5].

$$\text{LR} = T\sum_{t=1}^{r}\ln(1-\lambda_t^*) - \ln(1-\lambda_i^*) \quad \text{(viii)}$$

Where, $\lambda_1^*, \dots\dots\dots\dots\dots\dots\dots.. \lambda_r^*$ are the largest squared canonical correlations under the null hypothesis, the restricted model, the test statistics follows an asymptotic Chi-square distribution with the degree of freedom equaling the number of restrictions imposed.
The next step is to estimate the error correction model (ECM) which will be done in the next section.

Engel Granger Error Correction Model: From the results of either Engle- Granger test or Johansen co-integration test, if the price series under consideration are found to be co-integrated then, the residuals from the equilibrium regression can be used to estimate the error correction mechanism (ECM). It is performed with an intention to analyse the long term and short term effects of the variables as well as to find the speed of adjustment of disequilibrium to the original equilibrium condition. This coefficient is the lagged residual terms of the long run relationship. Its functional form is represented as below,

$$\Delta P_{1\,t} = C + \partial\, u_{\,t\text{-}1} + \beta\, \Delta P_{2\,t} + e_t \qquad \text{(ix)}$$

Where, e_t is identically and independently distributed (iid) and $\partial = (\alpha - 1)$ is the coefficient of the term $u_{\,t\text{-}1}$ which is the error correction coefficient and is also called the adjustment coefficient. It tells us how much of the adjustment to equilibrium takes place in each period, or how much of the equilibrium error is corrected. This error correction coefficient is expected to be negative and statistically significant. Because, if the error term is negative then only we can say that the two variables can converge to equilibrium. Convergence is a prerequisite for the presence of co-integration because if there is no convergence then the two variables cannot maintain a long run equilibrium relationship.

Granger Causality Test: The Granger causality test conducted within the framework of VAR model is used to test the existence and direction of long-run causal price relationship between the marketrs (Granger, 1969) [3]. It is an F-test of whwther changes in one price series affect another price series. Taking the causality relationship between International price and one of the domestic market price of mango as an example, the test was based on the following pairs of OLS regression equations through a bivariate VAR.

$$Pln\, D_t = \sum_{i=1}^{m} \alpha_i Pln\, I_{t-i} + \sum_{i=1}^{m} \beta_j Pln\, D_{t-j} + \varepsilon_{1t} \qquad \text{(x)}$$
$$Pln\, I_t = \sum_{i=1}^{m} \theta_i Pln\, D_{t-i} + \sum_{i=1}^{m} \delta_j Pln\, I_{t-j} + \varepsilon_{2t} \qquad \text{(xi)}$$

Where, D and I are Domestic and International markets, P *ln* stands for price series in logarithmic form and *t* is the time trend variable. The subscript stands for the number of lags of both the variable in the system. The null hypothesis in Equation (x), H_0: $\beta_1 = \beta_2 = \ldots\ldots = \beta_j = 0$ against the alternative, i.e., H_1: Not H_0, is that P $ln\, D_t$ does not Granger cause P $ln\, I_t$. Similarly, testing H_0: $\delta_1 = \delta_2 = \ldots\ldots = \delta_j = 0$ against H_1: Not H_0 in Equation (xi) is a test that P $ln\, I_t$ does not Granger cause P $ln\, D_t$. In each case, a rejection of null hypothesis will imply that there is Granger causality between the variables (Gujarati, 2010) [4].

Results and discussion

Co-integration between Lucknow market and International market: The co-integration analysis recognizes that the time series of prices for various markets are usually non stationary variables (Wang and Ke, 2005) [12] and if this series found to be non-stationary then it becomes necessary to test them for co-integration, which is pre condition for co-integration analysis. Also non integration among markets implies market in-efficiency (Wani *et al.*, 2015) [13]. The results of Augmented Dickey Fuller (ADF) unit root test applied at level and first difference to the logarithmically transformed prices of mango were given in table 1 (Beag and Singla, 2014) [1]. The empirical evidence suggests that price series had unit root at level form. The null hypothesis of the unit root at level form cannot be rejected for all price series as the absolute values of the ADF statistics was well below the 5 percent critical values of the test statistics. Thus it was observed that the both price series were non-stationary at their level forms. In order to test the level or number of unit roots in the data, a unit root test of first difference was conducted, which showed the number of unit roots to be equal to one, since the data became stationary after the first difference.

Table 1: ADF test for Lucknow market price

	Level data (ln L)		At first difference (◊ ln L)	
	t-statistic	Prob*	t-statistic	Prob*
ADF test value	-1.2757	0.6207	-2.8276	0.0453
1% level	-3.7880		-3.8867	
5% level	-3.0123		-3.0521	
10% level	-2.6461		-2.6665	

Table 2: KPSS test for Lucknow market price

	Level data (ln L)	At first difference (◊ ln L)
	LM-statistic	LM-statistic
KPSS test value	0.6463	0.0509
1% level	0.7390	0.7390
5% level	0.4630	0.4630
10% level	0.3470	0.3470

Table 3: PP test for Lucknow market price

	Level data (ln L)		At first difference (◊ ln L)	
	Adj. t-statistic	Prob*	t-statistic	Prob*
PP test value	-1.2316	0.6405	-6.2403	0.0001
1% level	-3.7880		-3.8085	
5% level	-3.0123		-3.0206	
10% level	-2.6461		-2.6504	

In this study, the export prices are considered to be the international prices. The export price is not only dependent on internal policy rather it also depends on international trade. So, due to unavailability of data from the mango market of any other country; export price was considered to be the international price for mango.

Table 4: ADF test for International price

	Level data (ln I)		At first difference (◊ ln I)	
	t-statistic	Prob*	t-statistic	Prob*
ADF test value	0.284	0.9715	-4.5810	0.0019
1% level	-3.788		-3.8085	
5% level	-3.012		-3.0206	
10% level	-2.646		-2.6504	

Table 5: KPSS test for International price

	Level data (ln I)	At first difference (◊ ln I)
	LM-statistic	LM-statistic
KPSS test value	0.7814	0.2267
1% level	0.7390	0.7390
5% level	0.4630	0.4630
10% level	0.3470	0.3470

Table 6: PP test for International price

	Level data (ln I)		At first difference (◊ ln I)	
	Adj. t-statistic	Prob*	t-statistic	Prob*
PP test value	0.1653	0.9632	-4.5683	0.0020
1% level	-3.7880		-3.8085	
5% level	-3.0123		-3.0206	
10% level	-2.6461		-2.6504	

The stationarity in international price series can be worked out with the help of ADF, KPSS and PP test and it was found to be non-stationary, which was the necessary condition for co-integration. The result revealed that the price series found to be stationary after first differencing. Time plot of mango price data reaveled that there was an increasing trend in both the data series (Pal *et al.*, 2007) [8]. The results of trend found in the data series were as follows;

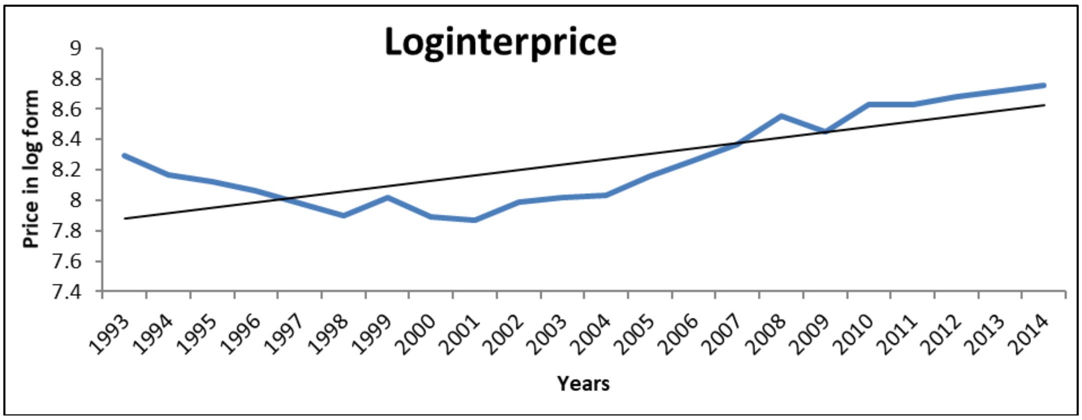

Fig 1: Time plot of International price (logarithmically transformed)

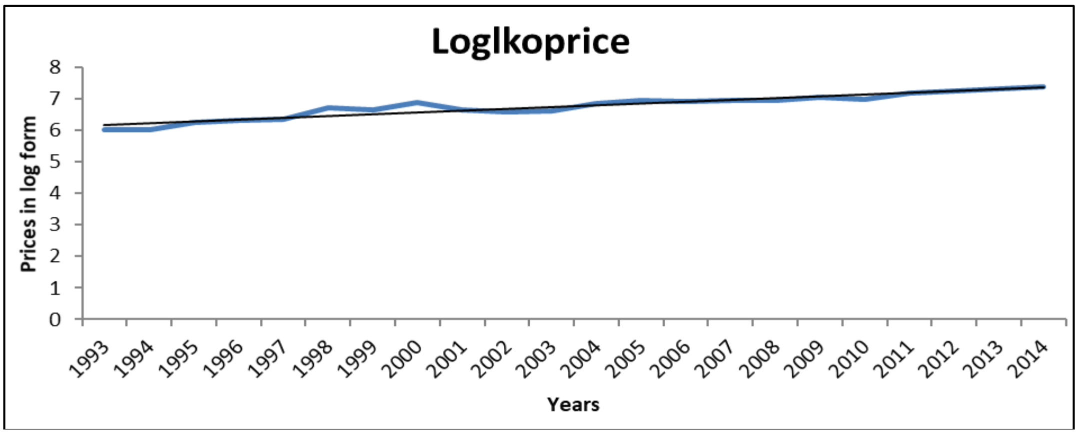

Fig 2: Time plot of Lucknow market price (logarithmically transformed)

From the figure 1 and figure 2 it was observed that there was trend in both the data series. Therefore, the staitionarity can also be observed through including trend and intercept component as exogeneous. In both the series coefficient was found to be significant at 1 per cent level of significance.

Table 7: Lginterprice time regression

Factors	Coefficients	Standard Error	t Stat	P value
Intercept	7.841	0.083	93.452	0.0000
Time	0.035	0.006	5.597	0.0000
R square = 0.6104				

Table 8: Lglkoprice time regression

Factors	Coefficients	Standard Error	t Stat	P value
Intercept	6.100	0.057	106.843	0.000
Time	0.057	0.004	13.191	0.000
R square = 0.8969				

The results of stationarity can be obtained with the help of three tests used above. After including trend and intercept as a exogeneous component, both the data series found to be non-stationary (Table 9, 10 and 11). In order to attain stationarity, 1st order differencing was done in both the data series.

Table 9: ADF test for Lucknow market price after including Trend and Intercept as exogenous

	Level data (ln L)		At first difference (◊ ln L)	
	t-statistic	Prob*	t-statistic	Prob*
ADF test value	-2.8375	0.2031	-2.9018	0.0018
1% level	-4.5715		-4.5715	
5% level	-3.6908		-3.6908	
10% level	-3.2869		-3.2869	

Table 10: KPSS test for Lucknow market price after including Trend and Intercept as exogenous

	Level data (ln L)	At first difference (◊ ln L)
	LM-statistic	LM-statistic
KPSS test value	0.2290	0.0736
1% level	0.2160	0.2160
5% level	0.1460	0.1460
10% level	0.1190	0.1190

Table 11: PP test for Lucknow market price after including Trend and Intercept as exogenous

	Level data (ln L)		At first difference (◊ ln L)	
	Adj. t-statistic	Prob*	t-statistic	Prob*
PP test value	-2.9202	0.1763	-6.1975	0.0004
1% level	-4.4678		-4.4983	
5% level	-3.6449		-3.6584	
10% level	-3.2614		-3.2689	

Table 12: ADF test for International price after including Trend and Intercept as exogenous

	Level data (ln I)		At first difference (◊ ln I)	
	t-statistic	Prob*	t-statistic	Prob*
ADF test value	-2.5967	0.2848	-5.6100	0.0011
1% level	-4.4678		-4.4983	
5% level	-3.6449		-3.6584	
10% level	-3.2614		-3.2689	

Table 13: KPSS test for International price after including Trend and Intercept as exogenous

	Level data (ln I)	At first difference (◊ ln I)
	LM-statistic	LM-statistic
KPSS test value	0.1640	0.1136
1% level	0.2160	0.2160
5% level	0.1460	0.1460
10% level	0.1190	0.1190

Table 14: PP test for International price after including Trend and Intercept as exogenous

	Level data (ln I)		At first difference (◊ ln I)	
	Adj. t-statistic	Prob*	t-statistic	Prob*
PP test value	-2.9148	0.1778	-5.6091	0.0011
1% level	-4.4678		-4.4983	
5% level	-3.6449		-3.6548	
10% level	-3.2614		-3.2689	

The results revealed that the series were found non-stationary at level form. In order to test the level or number of unit roots in the data, a unit root test of first difference was conducted, which showed the number of unit roots to be equal to one, since the data in both the series became stationary after the first difference as the absolute values of the ADF statistics were non-stationary and integrated of the order 1, the test for co-integration among the selected mango markets using Johansen's maximum likelihood approach was applied (Khatkar *et al.*, 2014) [6].

Table 15: Overall co-integration in Lucknow market prices and international prices

Hypothesized No. of CE (s)	Eigen value	Trace Statistics	Critical Value 0.05	Prob.**	Remarks (Trace indicate)
1-No intercept or trend in CE or test VAR					
None *	0.5072	20.5976	12.3209	0.0017	No cointegration
At most 1*	0.2753	6.4410	4.1299	0.0133	
2-Intercept (no trend) in CE- no intercept in VAR					
None *	0.5093	21.3364	20.2618	0.0355	1 cointegration
At most 1	0.2987	7.0964	9.1645	0.1214	
3-Intercept (no trend) in CE and test VAR					
None	0.4363	11.9481	15.4947	0.1594	No cointegration
At most 1	0.0237	0.4804	3.8414	0.4882	
4- Intercept and trend in CE- no intercept in VAR					
None	0.4952	22.4474	19.3870	0.1259	No cointegration
At most 1	0.3551	8.7733	12.5179	0.1948	
*denotes rejection of the the hypothesis at the 0.05 level					
**MacKinnon-Haug-Michelis (1999) [7] p-values					

The Johansen's Co-integration Test was carried out between both market and the results were given in Table 15. The study has found number of co-integrated equations using trace statistics and maximum eigen value statistics. In this case, the number of co-integrating vectors can be at most one as there were two series. According to probabilities given in tables 15, the results showed rejection of the null hypothesis that there is no co-integrated vector (None) and accepted the alternative hypothesis that there is at most 1 co-integrated vector in both trace statistics and maximum eigen value statistics as having no intercept in CE and no intercept in VAR. It shows long run association between Lucknow market price and International market price used in current study.

Estimates of Vector Error Correction Model Parameters: The foregone discussion suggest that even though the markets was integrated, there could still be disequilibrium in the short run due to the price adjustments across the markets, which might not happen instantaneously or simultaneously. The VECM model was estimated to know how far away the prices from the equilibrium level were and to account for this kind of adjustment Vector Error Correction Model could be an appropriate tool that takes into account the kind of adjustments in the short run and long run disequilibrium of prices in the distantly located markets. The results of the VECM model show that the estimated coefficients were negative for the selected markets. These coefficients measure the ability of the prices for adjustment to deviation from the short run equilibrium, which could be removed in every period of one month. Here, Negative sign of speed of adjustment term shows that the Lucknow market price of mango in India will converge towards long run equilibrium after taking 31 per cent monthly adjustments, but in International market it as very low and converge towards long run equilibrium after taking 14 per cent monthly adjustments.

$$y_{1t} = \alpha_0 + \alpha_1 y_{1t-1} + \alpha_2 y_{2t-1} + \alpha_3 ECT_{1t-1}$$
$$y_{2t} = \beta_0 + \beta_1 y_{2t-1} + \beta_2 y_{1t-1} + \beta_3 ECT_{2t-1}$$

Where,
y_{1t} = Lucknow Price
y_{2t} = International Price
( ) = t-statistics

$$y_{1t} = \frac{0.069}{(2.124)} - \frac{0.140}{(-0.624)} y_{1t-1} + \frac{0.390}{(1.207)} y_{2t-1} - \frac{0.319}{(-2.827)} ECT_{1t-1}$$

$$y_{2t} = \frac{0.032}{(1.404)} - \frac{0.1567}{(-0.681)} y_{2t-1} + \frac{0.003}{(0.019)} y_{1t-1} - \frac{0.146}{(-2.695)} ECT_{2t-1}$$

Table 16: Impact of International Price on Lucknow market price in long run

	Coefficient	Standard Error	t-statistic	P-value	R square
Intercept	5.0341	0.8889	5.6631	0.0000	0.3966
LKO Price	0.4761	0.1312	3.6262	0.0016	

The long run estimates of Lucknow market price is reported in table 16. The coefficient having positive sign is suggesting that 1 per cent increase in mango price in International market leads to 0.4761 per cent increase in mango price in Lucknow market in the long run. This finding is consistent with Worako *et al.* (2011) [14].

Causality in Lucknow market in International market: The co-integration tests performed indicate the existence of long run and short run relationship among the prices of the selected mango markets. The direction of the relationship among price series and market is equally important for which Granger Causality tests were performed. The results presented in Table 17. It shows the unidirectional causality revealed in the International market which lead to the prices in Lucknow market.

Table 17: Granger causality test statistics for selected mango markets

Null hypothesis	No. of lags	F-statistic	P-value	Relationship
L does not cause I	1	11.6008	0.0031	→
I does not cause L	1	2.1434	0.1604	

L = Lucknow market price, I = International market price, → denotes unidirectional relationship
*indicates significant at 0.05% level of probability

Conclusion

The results of co-integration test were revealed that there exists a long-run relationship between domestic and international prices of mango. The prices of Lucknow market showed the long term and short term relationship of mango with International market. The significant coefficient of at least one error correction term confirmed the results of co-integration between domestic and international prices of mango. The results of Vector Error Correction Model

(VECM) revealed that the coefficient of the error correction term was negative and significant in the selected markets. This implies that the prices are stable in the long-run and any deviation in their prices due to external shocks that occurred in the short-run was well adjusted by the market forces over time. Negative sign of speed of adjustment term shows that the Lucknow market price of mango in India will converge towards long run equilibrium after taking 31 per cent monthly adjustments, but in International market it as very low and converge towards long run equilibrium after taking 14 per cent monthly adjustments. The results of the model also revealed the existence of unidirectional causality in the International market which lead to the prices in Lucknow market. Therefore, the study needs to carry attention of the policy makers to strengthened the use of information technology for to flow the market information regularly and linked the 585 mandies by 2018 will help the farmers for increasing the income, also government should ensure the availability of reliable data on production, arrival and prices in particular APMCs.

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