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Research Paper

Market Integration and Causality: An Application to the Major Apple Markets in India

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ABSTRACT

Market integration and prices of fruit crops such as apple play an important role in determining the production decisions of apple farmers. In this context, the present study examines the degree of spatial market integration and price transmission across five major apple markets of the country, viz. Shimla, Chandigarh, Delhi, Bengaluru and Mumbai by adopting Johansen's Cointegration Test, Grangers Causality and Impulse Response Function. The outcomes of the study strongly buttress the cointegration and interdependence of the apple markets in India. To get additional information on whether and in which direction price transmission is occurring between market pairs, Ganger's Causality Test has been used, which has confirmed Shimla to be the price determining market as it has causal relations with all the selected markets. The Impulse Response Function supported that all the selected markets responded well to standard deviation shock given to any other market. The major implication of the study is further improvement in market integration situation through dissemination of price and arrival data efficiently and developing communication means with in the markets by the government.

Highlights

- The wholesale apple markets in India are well integrated and have long-run associations across them. The impulse response function revealed that the standard deviation shock given to any market is transmitted quickly to all the other markets.

Keywords: Apple, market integration, Johansen's cointegration test, price transmission

There are several impediments to the efficient functioning of markets in developing countries like India. These include insufficient transportation infrastructure, difficulties in accessing market information, government-imposed restrictions on the movement of goods between regions, government monopoly over the marketing and distribution system, and poor enforcement of anti-trust regulations that result in price-fixing and oligopolistic market structures. If markets are not well-integrated, then price signals could be distorted, which leads to an inefficient allocation of resources, and the marketable surplus generated by the farmers could result in depressed farm prices and diminishing income (Tahir and Riaz, 1997). Therefore, there is an immense need to modify traditional techniques or develop methods that would enable the markets to work efficiently and to make them more competitive. An intrusion by the government in marketing may be justified if it remedies the nearby imperfections. However, one way to throw some light on this issue is to analyze the market performance by studying market integration (Mukhtar and Javed, 2007).

Gafoor *et al.* (2009) define market integration can

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be measured in terms of strength and speed of price transmission across the various regions of the country. Varela *et al*. (2012) called it a degree to which consumers and producers would benefit depends on how domestic markets are integrated with world markets and how the regional markets are integrated with each other. Earlier, the price correlation coefficients and regression analysis were used by Timmer (1984) and Dadi *et al*. (1992). Alexander and Wyeth (1994) were used to explore whether or not markets were connected by price changes. However, price correlation coefficients can be misleading due to the existence of trends or unit roots in the data. The regression analysis in measuring market integration was customized using the time series variables in their first difference order, but this caused the loss of long-run information. Cointegration analysis, on the other hand, allows eliminating the presence of unit roots and safeguards from spurious results, thus enhancing the accuracy of research findings.

Although several studies have been done empirically using cointegration techniques which concerns the market integration of agricultural commodities in India Jha *et al*. (2005); Yogisha (2005); Ghosh (2012); Sekhar (2012); Reddy *et al*. (2012); Bhardwaj *et al*. (2015) and Wani *et al*. (2015) yet, a little work has been carried out in the way of empirically evaluating apple market integration in India. Deodhar *et al*. (2006) studied market integration across the wholesale apple markets in India and found that the markets were not integrated, but the main drawback of this study was the selection of period for the study. The selected study period had witnessed the lowest domestic apple production in India during the past two decades, and imports of apple were also lowest due to the imposition of 100 percent tariff rates on apple till 1999. Kar *et al*. (2004) reported that the Chennai, Delhi, and Mumbai wholesale apple markets are well integrated. Similar results have been reported by Baeg and Singla (2014) while studying market integration across five major wholesale apple markets, viz. Ahmedabad, Bengaluru, Delhi, Hyderabad, and Kolkata of the country.

Apple cultivation in India is confined mainly to the states of Jammu & Kashmir, Himachal Pradesh and Uttarakhand in the North-Western Himalayan region. The efforts are being made to popularize its cultivation in north-eastern states (Shilpa *et al.* 2019). Despite being cultivated in selected pockets, Apple is consumed throughout the country. India faces a supply gap in its domestic apple market due to the increasing demand from the growing middle class (Ali *et al*. 2018). Thus, the study of the nature and extent of market integration becomes more important where the markets are spatially dispersed. Against this backdrop, the present study on integration can be useful to the producers in knowing where, when and how much to sell, which in turn will have a bearing on their production strategies and hence resource allocation.

MATERIALS AND METHODS

The study has culled monthly wholesale price (₹/Quintal) data from five major apple markets, namely, Shimla, Chandigarh, Delhi, Bengaluru, and Mumbai, for a period of thirteen years (January 2005 to December 2017). All the relevant secondary data have been collected from the official website of the National Horticulture Board. The analytical tools used in the study are described below.

Unit root test of stationarity

The regression analysis of non-stationary time series produces spurious results, which can be misleading (Ghafoor *et al.* 2009). The most appropriate method to deal with non-stationary time series for estimating long-run equilibrium relationships is cointegration, which necessitates that time series should be integrated of the same order. Augmented Dickey-Fuller (ADF) is used to verify the order of integration for each individual series. The ADF test, tests the null hypothesis of unit root for each individual time series. The rejection of the null hypothesis indicates that the series is non-stationary and vice-versa (Dickey and Fuller, 1981). The number of the appropriate lag for ADF is chosen for the absence of serial correlation using and Shwartz Information Criterion (SIC). The ADF test is based on the Ordinary Least Squares (OLS) method and requires the estimation of the following model.

$$\Delta P_t = a_0 + \delta_1 t + \gamma P_{t-1} + \sum_{j=1}^{q} \vartheta_j \Delta P_{t-j} + \varepsilon_t$$

Where, P = the price in each market; Δ = difference parameter (i.e., $\Delta P_1 = P_t - P_{t-1}$, $P_{t-1} = P_{t-1} - P_{t-2}$ and P_{n-1}

$= P_{n-1)} - P_{n-2})$; α_0 = constant or drift; t = time trend variable; q = number of lag length and ε_t = pure white error term.

Johansen's Cointegration method

The maximum likelihood (ML) method of cointegration is applied to check long-run wholesale prices relation between the selected markets of India (Johansen, 1988); (Johansen and Juselius, 1990). The starting point of the ML method is the vector autoregressive model of order (k) and may be written as:

$$P_t = \sum_{i=1}^{k} A_i P_{t-1} + \mu + \beta_t + \varepsilon_t \left(t = 1,2,3\ldots\right)$$

Where π denotes the ($nx1$) vector of non-stationary or integrated at order one, i.e., I (1). The procedure for estimating the cointegration vectors is based on the error correction model (ECM) as given by:

$$\Delta P_t = \mu + \pi P_{t-1} + \sum_{i=1}^{k-1} \tau_i \Delta P_{t-1} + \beta \mu_t + \varepsilon_t$$

Where, $\Gamma i = -(I - \Pi i, -\ldots\ldots, T)$; $i = 1,2,\ldots\ldots K-1$;
$\Pi = -(I - \Pi i, -\ldots\ldots\ldots \Pi k)$

Both Γi and Πi are the nxn matrices of the coefficient conveying the short and long-run information respectively, μ is a constant term, t is a trend, and ε_t is the n-dimensional vector of the residuals that are identically and independently distributed. The vector ΔP_t is stationary means P_t is integrated at order one I (1), which will make unbalance relation as long as Π matrix has a full rank of k. In this respect, the equation can be solved by inverting the matrix Π–1 for P_t and as a linear combination of stationary variables (Kirchgässner, *et al*. 2012). The stationary linear combination of the P_t determines by the rank of Π matrix. If the rank r of the matrix Π $r = 0$ the matrix is null and the series underlying is stationary. If the rank of the matrix Π is such that 0 < rank of (Π) = $r < n$, then there are $n\ x\ r$ cointegrating vectors. The central point of Johansen's procedure is simply to decompose Π into two $n \times r$ matrices such that $\Pi = \alpha\beta'$. The decomposition of Π implies that the $\beta' P_t$ are r stationary linear combination.

(Johansen and Juselius, 1990) proposed two likelihood ratio test statistics (Trace and Max Eigen test statistics) to determine the number of cointegrating vectors as follows:

$$J_{trace} = -T \sum\nolimits_{i=r+1}^{N} \ln \ln \left(1 - \hat{\lambda}_1\right)$$
$$J_{\max} = -T \ln \left(1 - \hat{\lambda}_{r+1}\right)$$

Where r is the number of cointegrated vectors, $\hat{\lambda}_i$ is the eigenvalue and $\hat{\lambda}_{r+1}$ is the $(r + 1)^{th}$ largest squared eigenvalue obtained from the matrix Π and the T is the effective number of observation. The trace statistics tested the null hypothesis of r cointegrating vector(s) against the alternative hypothesis of n cointegrating relations. The Max Eigen statistic tested the null hypothesis ($r = 0$) as against the alternative of $r + 1$.

Granger causality test

The notion of the Granger causality is that if the two variables are integrated of order one, i.e., I(1), then the most accepted way to know the causal relationship between them is the Granger Causality proposed by (Granger 1969). The existing study also performed the Granger Causality test, which explained that the wholesale price in market A causes the price in market B if and only if the past values of market A provide additional information for the forecast of market B. The testing procedure of the Granger Causality involves three steps. In the first step, the order of integration was tested by applying the augmented Dickey-Fuller. After confirming the integration, (Johansen and Juselius, 1990) maximum likelihood approach was used to comprehend the cointegration between the markets. The Johansen cointegration test explained that if cointegration exists among the variables, then Granger causality must also exist either unidirectional or bidirectional. The Granger causality involves estimation of the simple form of vector autoregressive model (VAR) and is presented as follows:

$$P_t^A = \sum\nolimits_{i=1}^{m} \alpha_i P_{t-1}^A + \sum\nolimits_{j=1}^{m} \beta_i l P_{t-j}^B + \mu_{1t}$$
$$P_t^B = \sum\nolimits_{i=1}^{n} \gamma_i P_{t-i}^{SB} + \sum\nolimits_{j=1}^{n} \partial_i P_{t-j}^A + \mu_{2t}$$

Where P_t is the wholesale prices and scripts A and B indicate the two separate markets, t is the time trend, μ_A and μ_B are the error terms of both the model.

The above-mentioned two equations with respect to market *A* and *B* can be jointly tested using OLS and then conduct an *F*-test for the three different expressions.

***Expression* 1:** $[\delta_{11}, \delta_{12} \ldots \delta_n] \neq 0$ and $[\partial_{21}, \partial_{22}, \ldots \partial_n] = 0$

Expression 1 indicates the unidirectional causality from P_t^B to P_t^A denoted as $P_t^B \rightarrow P_t^A$.

***Expression* 2:** $[\delta_{11}, \delta_{12} \ldots \delta_n] = 0$ and $[\partial_{21}, \partial_{22}, \ldots \partial_n] \neq 0$

Expression 2 indicates the unidirectional causality from P_t^A to P_t^B denoted as $P_t^A \rightarrow P_t^B$.

***Expression* 3:** $[\delta_{11}, \delta_{12} \ldots \delta_n] \neq 0$ and $[\partial_{21}, \partial_{22}, \ldots \delta_n] \neq 0$

Expression 3 indicates the bidirectional causality between P_t^A to P_t^B denoted as $P_t^A \leftrightarrow P_t^B$.

When the sets of market A and market B coefficients are statistically significant, it is said to be Feedback, or bilateral causality (Gujarati, 2003). Unidirectional causality from market A to market B is indicated if the estimated coefficient on the lagged of market B is statistically different from zero and vice versa.

Impulse Response Function

Granger causality test provides only the direction of causality for the selected time span. However, it fails to demonstrate the effect of shock on future values. The impulse response function shows a specific point of time t_0, that a shock originates from one equation and proceeds through the system (Kirchgässner *et al*. 2012). Generalized impulse response function was initially developed by (Koop *et al*. 1996), and since then, many have added for the development of both the theory and application of it. The existing study also applied the generalized impulse response as given below:

$$IRF_{t+k} = \left(\mu, P_t, P_{t-1} \ldots\right) = E \mid P_{t+k} \mid P_t = p_t + \mu,$$

$$P_{t-1} = \left[p_{t-1} \ldots\right] - E\left[\frac{P_{t+k}}{P_t} = p_t, P_{t-1} = P_{t-1}\right]$$

Where, IRF_{t+k} = Impulse Response Function, lower case letters, i.e., *p* represent realized values, and *u* is the impulse shock P_{t-1} is the history.

RESULTS AND DISCUSSION

The descriptive statistics of monthly wholesale prices of apples for selected markets from January 2005 to December 2017 are presented in Table 1. The perusal of the table reveals that the minimum average prices varied from ₹ 1010.69 to ₹ 2183.29 per quintal in Shimla and Delhi markets, respectively, whereas the maximum average prices ranged between ₹ 11849.95 to ₹ 15191.52 per quintal in Chandigarh and Shimla market during the period of study. The highest average wholesale price was found in the Delhi market (₹ 6570.50/qtl) and the lowest in Chandigarh (₹ 3841.60/qtl) market. The analysis of the coefficient of variations showed that the highest variation was observed in the Shimla market (58.38%) followed by the Mumbai market (55.60%). The lowest variation in monthly wholesale price was found in Delhi (37.32%) and Bengaluru markets (38.66%).

Unit root test of stationarity

The market integration among the selected apple markets was analyzed using Johansen's cointegration method, which necessitates that the time series should be integrated at order one, i.e., I (1). Therefore, the standard Augmented Dickey-Fuller unit root test (ADF) was applied to determine the order of integration, and results have been presented in Table 2. The empirical evidence suggests that price series had unit root problems at their level form. The null hypothesis of the unit root at level form cannot be rejected for all the price series as absolute values of ADF statistics are well below the 5 percent critical values of test statistics. Thus, it is concluded that all the price series are 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 first differencing as absolute values of ADF statistics were greater than 5 percent critical values of the test statistic. Thus, the selected price series were integrated at order one, i.e., I (1), and the number of lag lengths was chosen as suggested by Schwartz Information Criterion (SIC).

Johansen's Cointegration Test

The results of Johansen's maximum likelihood approach (maximum eigen value and trace test) are given in Table 3. The Johansen's procedure for the apple markets of India was applied by following three steps, firstly appropriate lag length was chosen

Table 1 Descriptive statistics of monthly wholesale prices for selected markets

Market	Observations (No.)	Monthly Wholesale Price (₹/ Quintal)			Coefficient of variation (%)
		Minimum	Maximum	Mean	
Shimla	156	1010.69	15191.52	5250.70	58.38
Chandigarh	156	1116.89	11849.95	3841.60	50.87
Delhi	156	2183.29	13808.00	6570.50	37.32
Bengaluru	156	1050.86	13229.88	6192.20	38.66
Mumbai	156	1037.46	12188.00	4565.30	55.60

Table 2: ADF unit root test results for wholesale prices of apple (including intercept and no trend as exogenous)

Market	At level/first difference	t-cal.	(Prob.*)	Remarks
Shimla(S)	S	-0.62	0.86	Non-Stationary
	ΔS	-5.45**	0.00	Stationary
Chandigarh(C)	C	-0.93	0.905	Non-Stationary
	ΔC	-9.408**	0.00	Stationary
Delhi(D)	D	-1.175	0.218	Non-Stationary
	ΔD	-14.94**	0.00	Stationary
Bengaluru(B)	B	-0.97	0.29	Non-Stationary
	ΔB	-11.14**	0.00	Stationary
Mumbai(M)	M	-1.17	0.221	Non-Stationary
	ΔM	-12.02**	0.00	Stationary

*1. **indicate that unit root at level or in the first differences and rejection of null hypothesis at 1 percent as well as at 5percent significance. The (prob.*) denotes MacKinnon (1996) one-sided p-values; 2. Δ denotes the price series after first difference.*

Table 3: Joint cointegration in selected apple markets of India.

H_0	H_1	Trace Statistic			Max-Eigen Statistics		
		Trace Statistic	0.05 Critical Value	P-value	Max-Eigen Statistic	0.05 Critical Value	P-value
$r = 0$	$r \geq 1$	120.473*	69.818	0.00	42.266*	33.876	0.004
$r \leq 1$	$r \geq 2$	78.207*	47.85	0.00	35.738*	27.584	0.003
$r \leq 2$	$r \geq 3$	42.469*	29.797	0.001	25.473*	21.131	0.011
$r \leq 3$	$r \geq 4$	16.995*	15.492	0.029	13.306	14.264	0.07
$r \leq 4$	$r = 5$	3.689	3.841	0.054	3.689	3.841	0.054

Denotes rejection of the null hypothesis at 5 percent level of significance.

as suggested by SIC criteria, secondly, the order of integration was confirmed by using ADF test; in the third step, two tests i.e., Trace and Max Eigen tests of Johansen's approach based on the VAR (vector autoregressive model) were put into application to analyse the cointegrating vectors between selected apple markets. The first null hypothesis of Max Eigen statistics and Trace test, tests no cointegration (r = 0) against alternative hypothesis ($r \geq 1$) of at least one cointegrated equation prevailed in the VAR system. Both these tests rejected the null hypothesis of no cointegration. Maximum Eigen values and Trace test statistic values were found higher than 5 per cent critical values and accepted the alternative of one or more cointegrating vectors. Similarly, the null hypothesis from $r \leq 1$ to $r \leq 3$, for Trace statistic were rejected against the alternative hypothesis from $r \geq 1$ to $r \geq 3$, as their critical values are less than the test statistic and the corresponding probability values were also less than 0.05. This implies that Trace statistic gives four cointegrating equation in overall cointegration of apple markets, while, Max Eigen value Statistic gives only three cointegrating equations. Therefore, keeping in view both the tests, we considered three cointegrating equations out of five cointegrating equations indicating that they are well integrated, and price signals are transferred from one market to another to ensure efficiency. Thus, Johansen's cointegration tests have shown that even though the selected apple markets are geographically isolated and spatially segmented, they are well connected in terms of prices of apple, demonstrating that the apple markets have long-run price linkages across them. Kar *et al*. (2014) and Baeg and Singla (2014) have reported similar findings.

Granger Causality Test

The causal relation between the selected price series of apple markets was examined through Granger causality technique. Granger's causality shows the direction of price transmission between two markets and related spatial arbitrage, i.e., physical movement of a commodity to adjust the price differences (Gafoor *et al*. 2009). The results of Granger's causality are shown in Table 4, which shows that all the four F- statistics for the causality tests of wholesale prices in the Shimla market are statistically significant. The null hypothesis of no Granger's causality was rejected in the case of Shimla. Besides, Chandigarh has three, while Delhi and Bengaluru have two each, and Mumbai has one F-statistics statistically significant on other market prices.

The results of Granger's causality revealed that unidirectional causality was found between market pairs; Shimla-Chandigarh, Delhi-Chandigarh wholesale markets, meaning that a price change in the former market in each pair Granger cause price change in the latter market and same is not feedbacked by the price change in the former market in each pair. There exists bidirectional causality between Mumbai-Shimla, Delhi-Shimla, Bengaluru-Shimla, and Bengaluru-Chandigarh. In these cases, 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. Further, four market pairs, Delhi-Mumbai, Chandigarh- Mumbai, Bengaluru-Mumbai, and Bengaluru- Delhi, were found to have no direct causality between them.

Therefore, it was further concluded from the table that since all the four F-statistics for the causality tests of wholesale prices in the Shimla market are statistically significant. Therefore, the Shimla market is holding a key position in price determination in other markets.

Impulse Response Function

Impulse response function was used to determine the relative strength of causality effect beyond the selected time span, as causality tests are

Table 4: Pair-wise granger causality in major apple markets

Null hypothesis	F-statistics	Probability	Granger cause	Direction
M does not Granger cause S	3.50065	0.0327**	Yes	
S does not Granger cause M	3.11909	0.0471**	Yes	Bidirectional
D does not Granger cause S	5.53587	0.0048**	Yes	
S does not Granger cause D	3.79270	0.0247**	Yes	Bidirectional
C does not Granger cause S	0.19166	0.8258	No	
S does not Granger cause C	18.4433	0.00000007**	Yes	Unidirectional
B does not Granger cause S	7.01481	0.0012**	Yes	
S does not Granger cause B	12.8781	0.000007**	Yes	Bidirectional
D does not Granger cause M	0.7290	0.4841	No	
M does not Granger cause D	1.85152	0.1606	No	No Causality
C does not Granger cause M	2.96872	0.0544	No	
M does not Granger cause C	2.30320	0.1035	No	No Causality
B does not Grange cause M	2.4471	0.09	No	
M does not Granger cause B	2.8739	0.0596	No	No Causality
C does not Granger cause D	3.60667	0.0295	No	
D does not Granger cause C	7.30842	0.0009**	Yes	Unidirectional
B does not Granger cause D	2.47815	0.0874	No	
D does not Granger cause B	1.22784	0.2959	No	No Causality
B does not Granger cause C	9.78757	0.0001**	Yes	Bidirectional
C does not Granger cause B	7.74584	0.0006**	Yes	

*The lags of the dependent variable used to obtain white-noise residuals were determined using the Schwarz Information Criterion (SIC); **denotes rejection of the null hypothesis at 5 percent level of significance.*

inappropriate because these tests are unable to show how much feedback exists from one variable to the other beyond the selected sample period (Rehman and Shahbaz, 2013). The best way to interpret the implications of the models for the patterns of price transmission, causality, and adjustments is to consider the time paths of prices after exogenous shock i.e., impulse response. The impulse response function explicates the responsiveness of one of the endogenous variables due to the shock on the current and future values of all the other endogenous variables in the VAR system. The shock affects the variable itself and is transmitted to the rest of the explanatory variables (Bhanumurthy *et al*. 2012). The results of impulse response function analysis are presented in Fig. 4.11(a) to 4.11(e). Figure 4.11(a) presents the response of Shimla to a standard deviation shock given to Mumbai, Chandigarh, Delhi and Bengaluru apple prices. The Shimla apple prices reacted to it immediately, plummeting initially for 4 to 5 months and then stabilized for the remaining period.

The results of impulse response function in Chandigarh market were almost similar to those of Shimla market, i.e., the prices dropped immediately during the past 4 months but stabilized thereafter. In Delhi, market price shock of one-unit standard deviation resulted in an immediate decline in prices which then stabilized after 4 to 5 months. The wholesale prices in the Delhi market were observed to be inversely related to those of the Mumbai market for the initial 5 months. In the Bengaluru market, the results of the impulse response function revealed a sharp decline in prices. Similarly, the wholesale prices in the Mumbai market were observed to be inversely related to Bengaluru up to the first 3 months. In the Mumbai market, prices reacted immediately by going down and then stabilized after 4 to 5 months. The overall results of the impulse response function explicate that the responses exhibit large magnitudes over 2600 unit standard deviations. Moreover, the price information process is quick for all the selected apple markets as they respond immediately to a shock that seems to fade away in 4 to 5 months.

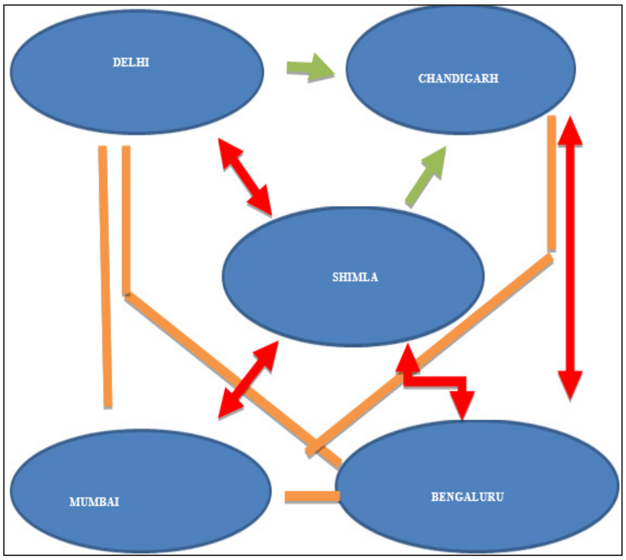

Fig. 1: Franger causality direction between market pairs impuse response function

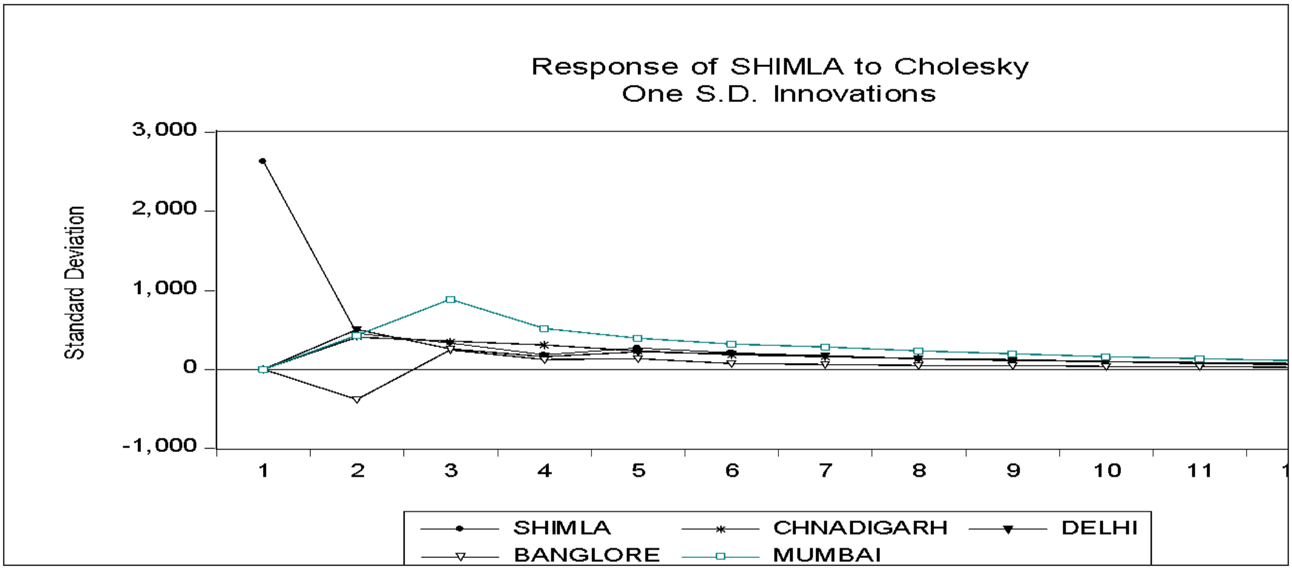

Fig. 2(a): Response of Shimla to cholesky one standard deviation shock

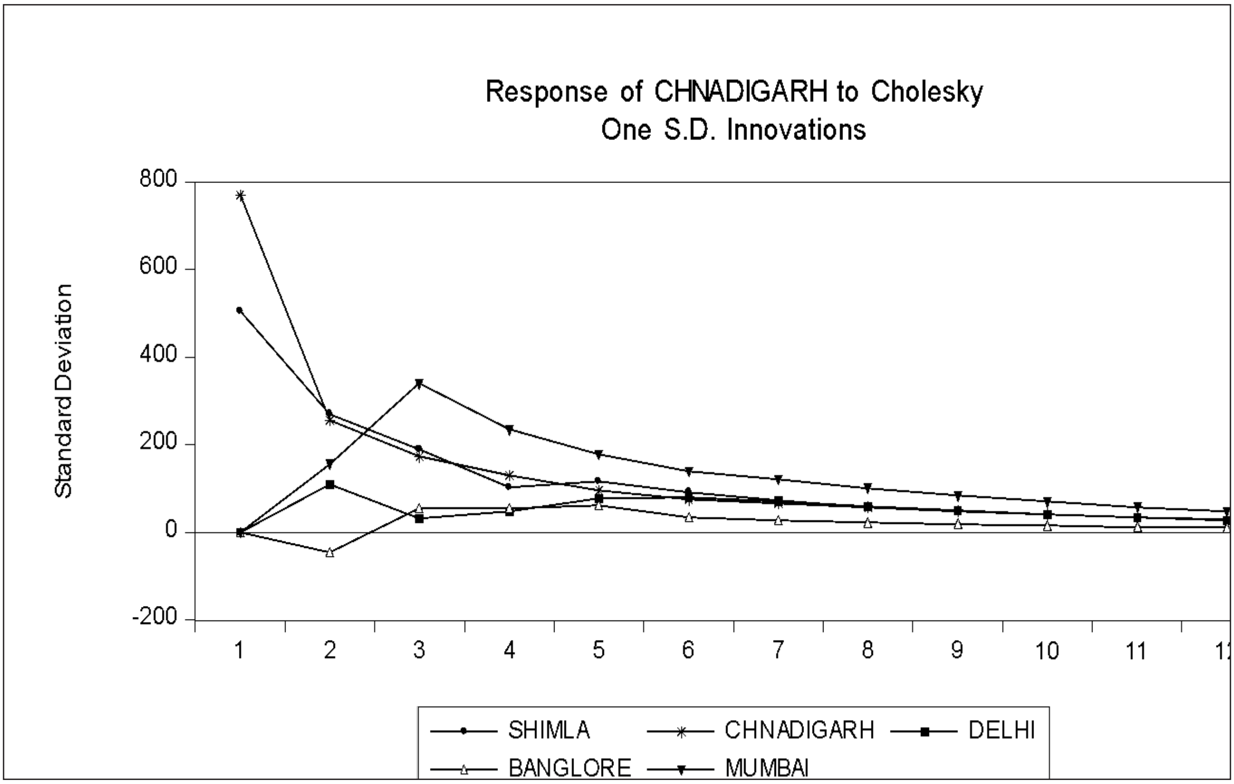

Fig. 2(b): Response of Chandigarh to cholesky one standard deviation shock

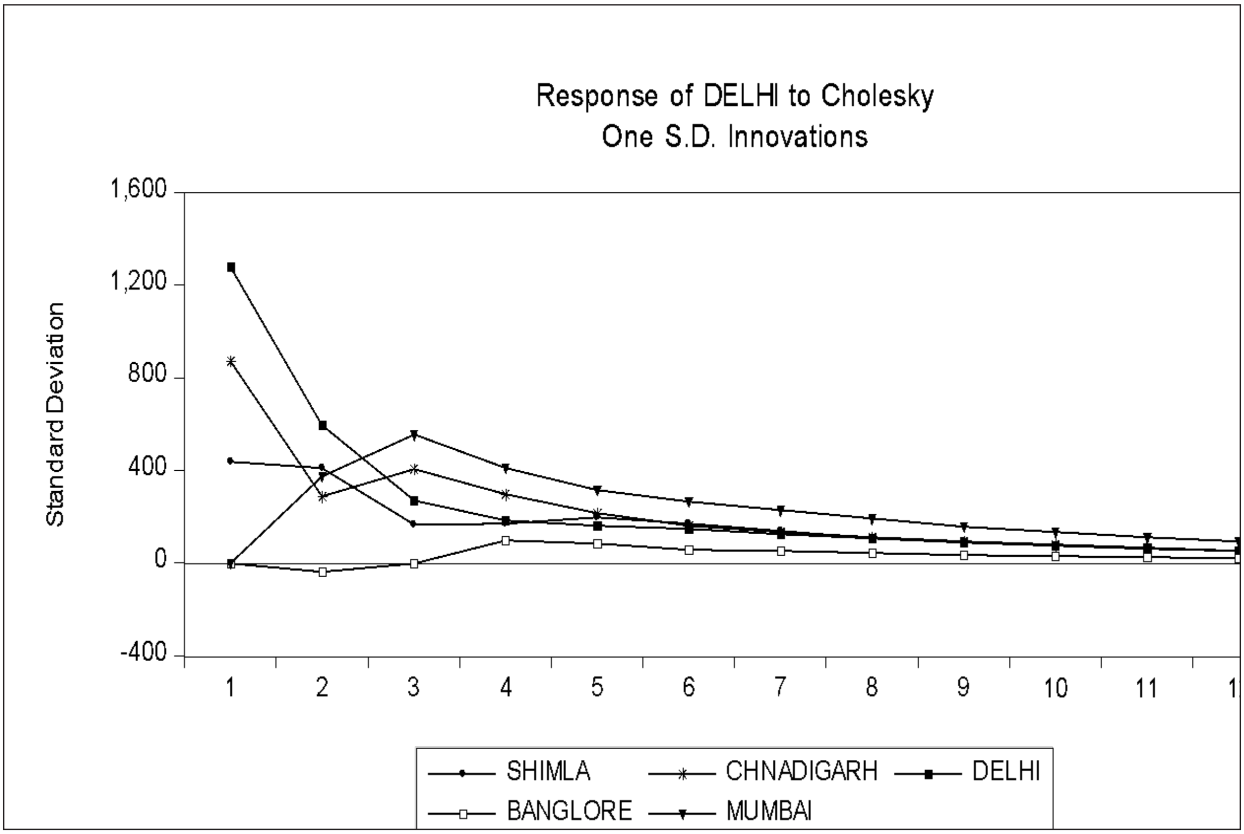

Fig. 2(c): Response of Delhi to cholesky one standard deviation shock

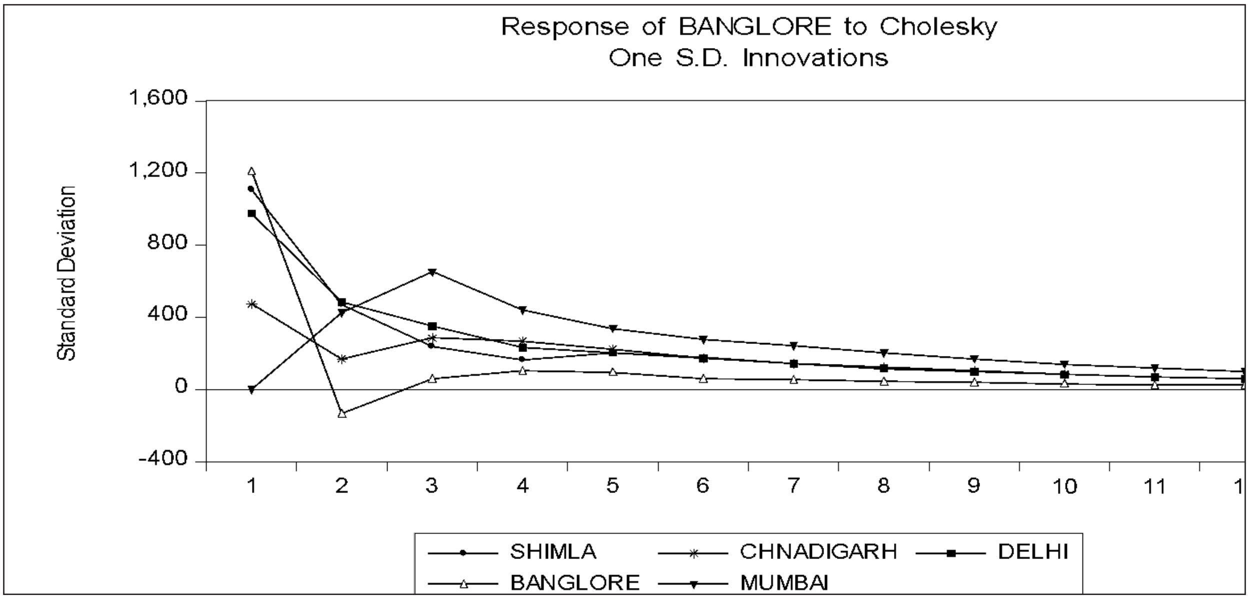

Fig. 2(d): Response of Bengaluru to cholesky one standard deviation shock

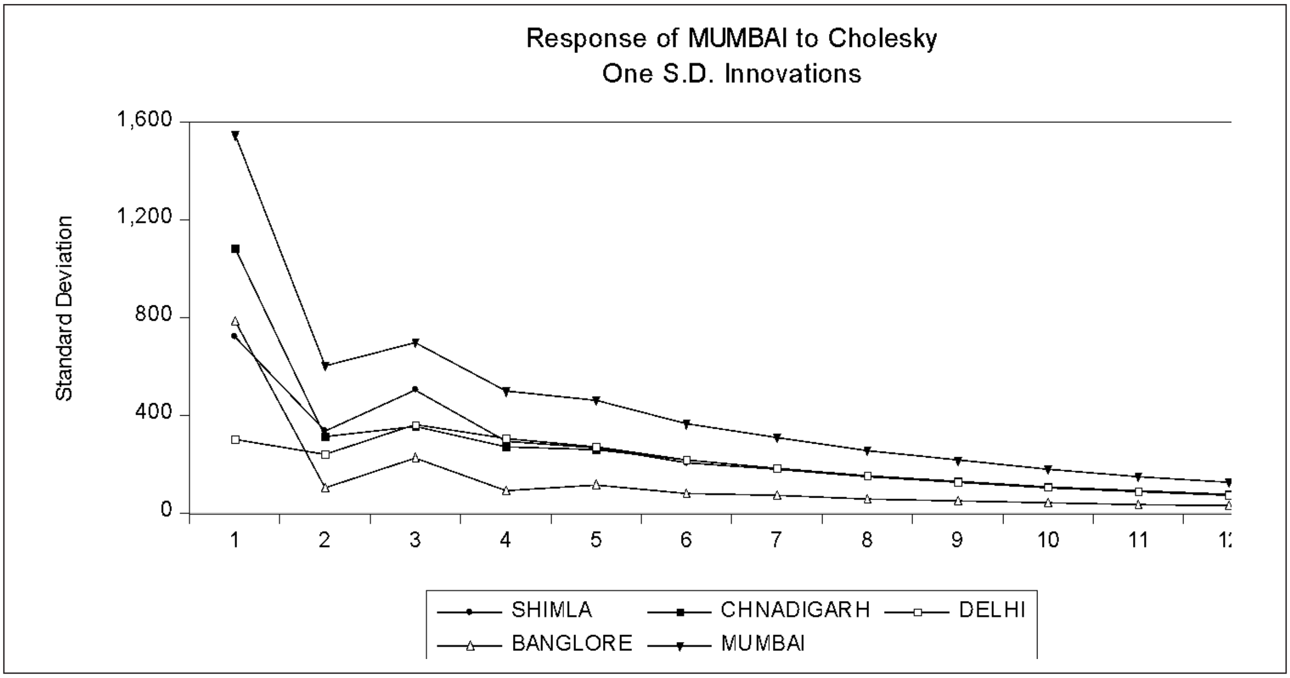

Fig. 2(e): Response of Mumbai to cholesky one standard deviation shock

CONCLUSION

The results of the overall cointegration test indicate that different wholesale apple markets in the country are well integrated and have long-run association across them. Granger causality test has indicated that, unlike the other market pairs, four market pairs, namely, Delhi-Mumbai, Chandigarh-Mumbai, Bengaluru-Mumbai, and Bengaluru-Delhi, have no causality direction on price formation between them. The impulse response function, revealed that the standard deviation shock given to any market is transmitted quickly to all the other markets. Therefore, the overall results of the study suggest that wholesale markets for apple are strongly integrated, although geographically isolated. The major implication of the study is further improvement in the market integration situation through the dissemination of price and arrival data efficiently and developing communication means within the markets by the government.

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