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Spatial Price Transmission in Kinnow Markets of Rajasthan State of India

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Abstract

The study focused on assessing the spatial price transmission between kinnow markets pairs in Rajasthan state of India using weekly kinnow price series of 8 markets from 2010-2015. Coefficient of variance results indicates Jaipur market has lowest price volatility which is represented by 17.56 % compared to 41.10 % in Sri Ganganagar market, which has the highest. The co-integration tests result indicates Ganganagar"↔ Alwar Ganganagar ↔ Ajmer, Ludhiana ↔ Jaipur, Ludhiana ↔ Jodhpur, Ludhiana ↔ Ajmer market pairs are not integrated in the long run. However, Ganganagar ↔ Bikaner, Ganganagar ↔ Delhi, Ganganagar ↔ Jodhpur, Ganganagar ↔ Ludhiana, Ganganagar ↔ Jaipur and Ludhiana ↔ Delhi are integrated in the long run. The results from the error correction model shows, there is short run unidirectional causality of Ganganagar → Bikaner and Ganganagar → Jodhpur. The lowest speed of adjustment towards long run equilibrium was from Ganganagar to Bikaner at rate of 0.2 percent. The speeds of adjustment running Ganganagar to Ludhiana and Ganganagar to Delhi markets towards long run equilibrium were 198 percent and 184 percent respectively in a period of 1 week at most. The speed of adjustment from Ganganagar to Jodhpur is 16.4 percent whereas Ganganagar to Jaipur is 10.4 %. The results shows there is no short run causality between the market pairs of Ganganagar ↔ Alwar and Ludhiana ↔ Jodhpur. On the other hand, the results show a unidirectional causality of some market pairs namely Ganganagar → Ajmer, Ludhiana → Jaipur and Ludhiana → Ajmer. The impulse response function shows that an unexpected shock in the prices of kinnow in Ganganagar will have a permanent lasting effect on prices of the various markets within a period of 4 weeks except Ajmer market prices.

Keywords: Kinnows, error correction model, unrestricted vector autoregressive model, co-integration analysis, Rajasthan, speed of adjustment, volatility

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Major fruit crops produced in India include banana, mango, citrus and papaya with 32.6 %, 22.1 %, 12.4 % and 6.6 % contributions respectively. The total citrus production in India is 11,636,000 metric tonnes for 2014-15. The leading citrus producing fruits in the country are lime and lemon, sweet orange and mandarin (m.orange, kinnow, orange).

Rajasthan state in India produced 717,000 metric tonnes of fruit in 2013-2013. It is the fifth (5th) citrus producing state in the country with production of 456,000 metric tonnes on an area of approximately 25,000 hectares which shows contribution of 4.5% to the national citrus production (National Horticulture Board, 2013).

The major varieties of citrus grown in the state are mainly mandarin and kinnow. Sri Ganganagar and Hanumangarh are known for kinnow whereas Jhalawar for Nagpur mandarin varieties production. Among the varieties of citrus produce not only in the state but also in the country, kinnow mandarin stands highest place in juice content and fruit quality. In the state, kinnow is grown mainly in Sri Ganganagar with 8650 hectares area and 25000 metric tonnes of production followed by Hanumangarh district (Anonymous, 2008).

National Horticulture Board under the Government of India underscores the importance of kinnow production in the state especially Sri Ganganagar and Hanumangarth in terms of employment generation, provision of vitamin C for locals, raw material production for industries; propose food parks and its aid in poverty reduction. In addition it also facilitates rural development and reduction of poverty among small

Table 1: India citrus varieties production figures

	Variety of Citrus Production('000 metric tonnes)				
Year	**Lime/Lemon**	**Mandarin(M. Orange, Kinnow, Orange**	**Sweet Orange**	**Others**	**Total**
2011-2012	2272.11	3128.48	1231.86	1289.63	7922.07
2012-2013	2523.51	2906.31	3519.91	1140.01	100089.73
2013-2014	2835.02	3431.41	3886.20	994.43	11147.06
2014-2015	2884.00	3708.00	4002.00	1042.00	11636.00

Source: http://nhb.gov.in/area%20_production.html

holder farmers (Irz *et al.*, 2001; Krishna, 2004; Krishna *et al.*, 2004). At the same time, the growing segment of middle-income households also provides a significant consumer base for locally process kinnow not forgetting the exponential growing demand for kinnow fruits and its products worldwide.

The Government of India realizing the importance of the citrus industry, established about 25 years ago the National Research Centre for Citrus with the agenda of developing and disseminating the required technologies for enhanced productivity of quality fruits through activities such as development of infrastructure, initiating research projects in citrus e.g. distribution of disease free planting material to growers and nursery owners etc. (Anonymous, 2014).

Rajasthan state which is a beneficiary of the activities of National Research Centre for Citrus has comparative advantage in the production of kinnow in the districts of Sri Ganganagar and Hanumangarth and other districts which have irrigated farm lands. However, the state has lower competitiveness compared to Haryana and neighbouring State Punjab because of inadequate infrastructure, high cost of capital, inadequate irrigation, poor skills of producers in meeting external quality standards, poor logistic management and inadequate marketing opportunities for the produce; poorly integrated markets which conveys inaccurate price information, lack of market intelligence and price fluctuations (Singh, 1996). There are also problems of malpractices in buying and selling affecting the distributive justice and efficiency of the kinnow marketing system (Verma and Singh, 2005) leading to inefficient product movements (Goodwin and Schroeder, 1991) and marketing inefficiencies (Yisa, 2009) in the state of Rajasthan.

This is not surprising because Sharma (2002) argued that in countries such as Pakistan, India, Sri Lanka and Indonesia, where governments intervene in domestic markets through policy interventions, the speed of adjustment towards long run equilibrium is as low as 1%-7%.

In spite of these challenges in the kinnow value chain, to date, there is no empirical research evidence of what extent price transmission can be considered as efficient across different kinnow district markets and how these markets are integrated. This research therefore seeks to find out how kinnow markets in Rajasthan are integrated.

Data Base and Methodology

The secondary data of weekly kinnow prices of the various kinnow arrival markets were obtained from various APMCs, AGMARKNET websites and Rajasthan Horticultural Board and National Horticultural Board website. Six markets were purposively selected based on highest market arrivals and number of days of arrivals. The six markets namely Sri Ganganagar, Jodhpur, Jaipur, Bikaner, Ajmer and Alwar in Rajasthan were selected for the study of market integration analysis. In addition, Delhi market was selected because the majority of the pre-harvest contractors and wholesalers of kinnow sold their fruit in this market. Ludhiana market was also selected because Ludhiana and Delhi markets are the highest consuming markets in the North of India (Mavi *et al.*, 2012). Sri Ganganagar was market used as production market whereas the rest were used as consumption markets for the market integration analysis. The data cover weekly kinnow prices from January 2010 to February 2015. The data set covers peak periods of kinnow i.e. January, February, March, November and December of each year. In all they were cumulative 108 observations. This period covers post WTO agreement era in India where a lot of programs, policies and strategies by various governments have been adopted to revamp kinnow production and marketing both in at the state level and National level. In addition, the wide data were selected to increase the potency of the models used in the analysis and also represent the availability of kinnow market price series for various markets. The price series are in Rupees per quintal for all the markets and all the years.

Market integration is generally is assumed to mean that prices changes in one market will be fully transmitted to the other markets. Markets that are not integrated may convey inaccurate price information that might distort marketing decisions and contribute to inefficient product movements (Muhammad, 2004). Several empirical techniques have been developed and used to investigate spatial market integration. Example is: the simple one-to-one correlation analysis (Lele, 1971; Blyn, 1973). According to Blyn (1973) a pioneer of the correlation method, high price correlations between markets are assumed to indicate market integration and the reverse stands for market segmentation. The model has short falls for instance; the prices in different markets might be highly correlated even if markets do not trade with each other. This can be because of common destination or common factors influencing prices. The correlation method also fails to capture time lag in price transmission.

To examine the price co-movements between two markets, the following approach was used to test the existence of market integration. This approach was adopted from Abdulai (2007); Mafimisebi *et al.* (2014); Kwasi and Kobina (2014).

$$P_1 = b_0 + a_2 P_2 + \varepsilon_t \quad (1)$$

Where P_1 and P_2 are price series of a specific kinnow in two the consuming market and the producing markets (1 and 2), and ε_t is the residual term assumed to be distributed independently. Parameter b_0 indicates transportation, handling and markets costs etc. The test of market integration is straightforward if P_1 and P_2 are stationary variables. Often, however, economic variables are non-stationary.

A stationary series is one with a mean value which will not vary with the sampling period. In contrast, a non-stationary series will exhibit a time varying mean (Juselius, 2006). Before examining integration relationships between or among variables, it is essential to test for unit root and identify the order of stationarity, denoted as I(0) or I(1). This is necessary to avoid spurious and misleading regression estimates. The framework of ADF methods is based on analysis of the following model.

$$\Delta pt = \alpha + \beta p_{t-1} + 1 + yT + \sum_{k=1}^{n} \delta_k \Delta P_{t-k} - k + u_t \quad (2)$$

Here, p_t is the kinnow price series being investigated for stationarity, Δ is first difference operator, T is time trend variable, μ_t represents zero-mean, serially uncorrelated, random disturbances, k is the lag length; α, β, γ and δ_k are the coefficient vectors. Unit root tests is conducted on the β parameters to determine whether or not each of the series is more closely identified as being I(1) or I(0) process. Test statistics is the t statistics for β. The test of the null hypothesis of equation (1) shows the existence of a unit root when β=1 against alternative hypothesis of no unit root when $\beta \neq 1$. The null hypothesis of non-stationarity is rejected when the absolute value of the test statistics is greater than the critical value. When p_t is non-stationary, it is then examined whether or not the first difference of pt is stationary (i.e. to test $\Delta p_t - \Delta p_{t-1} \approx$ (1) by repeating the above procedure until the data were transformed to induce stationarity.

DF-GLS test for a unit root in a time series is deployed in addition to Augmented Dickey Fuller (ADF) and Philips-Perron (PP) test. It performs the modified Dickey–Fuller t test (known as the DF-GLS test) proposed by Elliott, Rothenberg and Stock (1996). Essentially, the test is an Augmented Dickey–Fuller test, similar to the test performed by Stata's dfuller command, except that the time series is transformed via a generalized least squares (GLS) regression before performing the test.

Elliott, Rothenberg, and Stock and later studies have shown that this test has significantly greater power than the previous versions of the augmented Dickey–Fuller test.

The Philips-Perron (PP) test is similar to the ADF test. PP test was conducted because the ADF test loses its power for sufficiently large values of "k", the number of lags. It includes an automatic correction to the Dickey-Fuller process for auto-correlated residuals. The regression is as follows:

$$\Delta p_t = b_0 + b_1 p_{t-1} + u_t \quad (3)$$

Where p_t is the kinnow price series being investigated for stationarity, b_0 and b_1 are the coefficient vectors and u_t is serially correlated. Testing for Johansen co-integration (trace and eigenvalue tests): If two series are individually stationary at same order, the Johansen co-integration model can be used to estimate the long run co-integrating vector using a Vector Auto regression (VAR) model of the form:

$$\Delta p_t = a \sum_{i=1}^{k-1} \lceil i \Delta P_{t-1} + \cap p_{t-1} + u_t \quad (4)$$

Where p_t is a nx1vector containing the series of interest (kinnow price series) at time (t), Δ is the first difference operator $\lceil i$ and $\cap$ are nxn matrix of parameters on the i^th^ and k^th^ lag of,

$$p_t, \lceil i = \left[\sum_{i=1A_i}^{k} \right] - I_g, \Pi = \left[\sum_{i=1A_i}^{k} \right] - I_g, I_g \quad (5)$$

Ig is the identity matrix of dimension g, α is constant term, $\Delta\mu_t$ is nx1 white noise error vector. Throughout, p is restricted to be (at most) integrated of order one, denoted I(1), where I(j) variable requires *j*th differencing to make it stationary. Equation (2) tests the co-integrating relationship between stationary series. Johansen and Juselius (1990) and Juselius (2007) derived two maximum likelihood statistics for testing the rank of Đ, and for identifying possible co-integration as the following equations show:

$$\lambda_{trace}\left[r\right] = -T\sum_{i=r+1}^{m} In\left(1-\lambda\right) \qquad (6)$$

$$\lambda_{\max}\left[r, r+1\right] = -TIn\sum_{i=r+1}^{m} In\left(1-\lambda\right) \qquad (7)$$

Where r is the co-integration number of pair-wise vector, λ_t is ith eigenvalue of matrix Đ. *T* is the number of observations. The λ_{trace} is not a dependent test, but a series of tests corresponding to different *r*-value. The λ_{max} tests each eigenvalue separately. The null hypothesis of the two statistical tests is that there is existence of r co-integration relations while the alternative hypothesis is that there is existence of more than r co-integration relations. This model was used to test for; (1) integration between pair-wise price series of local kinnow prices in the selected markets in the central state.

Impulse response function is a shock to both VAR and ECM models used in the analysis. Impulse responses identify the responsiveness of the dependent variable which is (endogenous variables) in the models when a shock is put to the error term. A simplified model of impulse response function for Ganganagar against Delhi market prices can be written as:

$$Ganganagar_t = B_0 + B_1 Delhi_{t-1} + \ldots + B_h Ganganagat_{t-h} + U_t \qquad (8)$$

Where U_t is error term or impulse or shock. Hence the model will give us the effect on the VAR system when a unit shock is applied to variables.

After undertaking co-integration analysis of the long run linkages of the various market pairs, and having identified the market pair that are linked, an analysis of statistical causation will be conducted. The causality test uses an error correction model (ECM) of the following form:

$$p_t^i = \beta_0 + \beta_i p^i\left(t-1\right) + \beta_2 p^j\left(t-1\right) + \sum_{k=1}^{m} \delta_k \Delta p^i\left(t-k\right) +$$
$$\sum_{h=1}^{n} \Delta\sigma\Delta_h h\Delta p^j\left(t-h\right) + u_t$$

Where m and n are number of lags determined by Akaike Information Criterion (AIC).If the null hypothesis that prices in market j do not Granger cause prices in market i is rejected (by a suitable F-test) that $\sigma_h = 0$ for h = 1, 2….n and β=0, this indicates that prices in market j Granger-cause prices in market i. If prices in i also Granger cause prices in j, then prices are said to be determined by a simultaneous feedback mechanism (SFM). This case is then referred to as bi-directional Granger causality. If the Granger-causality is in only one direction, it is called uni-directional Granger-causality and the market which exhibited sufficient strength to have Granger-caused the other is referred to as the exogenous market (Mafimisebi *et al.*, 2012).

Lagrangian Multiplier tests (LM) was used to test for h-th order of residual correlation in the VECM and VAR models. The LM test assumes this model:

$$Ut = B_1 U_{t-1} + \ldots + B_h U_{t-h} + error_t \qquad (9)$$

Where $H_0 : B_1 = \ldots = B_h = 0$ and $H_1 : B_1 \neq 0$ or $B_h \neq 0$

The LM statistics can be written as:

$$LM_h = T\left[K - tr\left(\sum_R^{-1}\sum_e^{-1}\right) \approx X^2\left(hk^2\right)\right] \qquad (10)$$

A typical approach to testing departure from normality is to check the third and fourth moments of the random variables. This test was necessary because the VAR and ECM models assumed the errors in the equations are normally distributed. For a normal distribution, the measure of skewness S is zero (0) and the measure of kurtosis K is three (3). The definitions of S and K are:

$$S = \frac{U_3^2}{U_2^3} \text{ and } K = \frac{U_4}{U_2^2} \qquad 11$$

Where, U_2, U_3 and U_4 are the second, third and fourth moments about the mean, respectively. Using S and K based on least square residuals. The JB test statistic can be written as:

$$JB = n\left[\frac{S^2}{6} + \frac{\left(K-3\right)^2}{24}\right] \qquad 12$$

Jarque-Bera (JB) test is a popular diagnostic tool in practice especially with regards to time series data like price series because it is an asymptotic test that is applicable in large samples only.

Results and Discussion

Table 2 presents the mean, maximum, minimum, coefficient of variation and number observations in the data set. The prices series are from 2010-2015. The results are presented below. The results from Table 2 above, shows, the mean price of kinnow in Indian Rupees (₹) per quintal from the period of 2010-2015 for the six (6) markets across Rajasthan and two (2) outside the state was lowest at ₹ 921.94 in Jodhpur market. The highest average was recorded at price of ₹ 1864.30 in Delhi market which was expected. The minimum price was recorded in Sri Ganganagar market, at price of ₹ 283.27 which was expected because it is the main production hub of kinnow in the state. Also the maximum was price recorded in Delhi market, at price of ₹ 5777.00. Coefficient of variance or variation which was used to measure the volatility of kinnow market prices indicates Jaipur market has lowest price volatility which is represented by 17.56% compared to 41.10% in Sri Ganganagar market, which has the highest. The high volatility in Sri Ganganagar market can be attributed to a lot of things among which include the high concentration of production in the area and the pressure thereof on the produce from various actors of the kinnow value chain. Again, the production of kinnow or kinnow fruits meets a strong competition from Nagpur mandarin which is preferred mostly to kinnow.

Hence when the fruit of Nagpur mandarin is available in the market, it has a negative effect on the prices of kinnow. In addition, during the peak season of kinnow especially in the months of November to December, the weather is very chilly hence consumers hesitate to take kinnow till February to March when the chilly weather is quite less compared to the former. It also worth to note that early harvesting of kinnow sometimes from October by some pre-harvest contractors and farmers affect the quality of kinnow which might not have matured enough for better prices. The variation in kinnow arrivals to the market is also a contributing factor. Thus, price variation can be related to the trend of arrival levels which shows fluctuations over time and are called as temporal variation, and the other comprises

Table 2: Descriptive statistics of Kinnow price series (2010-2015)

Markets	Obs.	Mean(₹/qt)	Std. Dev.	Min(₹/qt)	Max(₹/qt)	$CV = \frac{Stdded}{Mean} * 100\%$
Bikaner	108	1459.90	553.38	373.64	3890.88	37.90
Jodhpur	108	921.94	185.32	568.47	1649.89	20.10
Ganganagar	108	1194.96	490.17	283.27	3645.90	41.10
Ajmer	108	1267.91	421.95	479.67	2363.84	33.28
Alwar	108	1486.22	464.43	422.75	3322.05	31.25
Jaipur	108	1378.73	241.98	902.91	2589.82	17.56
Ludhiana	108	1184.76	417.76	771.11	3600.00	35.26
Delhi	108	1864.30	732.29	860.02	5777.00	39.28

Source: Authors own computation, 2015

Table 3: Bivariate correlation matrix of price series

	Ganganagar	Bikaner	Jodhpur	Ajmer	Alwar	Jaipur	Ludhiana	Delhi
Ganganagar	1.00							
Bikaner	0.603* 0.000	1.000						
Jodhpur	0.419* 0.000	0.536* 0.000	1.000					
Ajmer	0.0761 0.434	-0.0697 0.474	0.2441* 0.011	1.00				
Alwar	0.730* 0.000	0.589* 0.000	0.438* 0.000	-0.215* 0.000	1.00			
Jaipur	0.589* 0.000	0.771* 0.000	0.596* 0.000	0.272* 0.005	0.594* 0.000	1.000		
Ludhiana	0.809* 0.000	0.659* 0.000	0.546* 0.000	-0.108 0.265	0.727* 0.000	0.689* 0.000	1.000	
Delhi	0.820* 0.000	0.549* 0.000	0.547* 0.000	0.0205 0.834	0.728* 0.000	0.694* 0.000	0.834* 0.000	1.000

Source: Authors own computation, 2015, * means significant at 5%

of fluctuations over the space and are called as spatial variation. These two kinds of price variations play a significant role in cropping pattern of the farmers as well as in the stability of income in the agriculture sector.

Large fluctuations in the prices of a commodity may result in switching over of farmers to some other remunerative crops. On the other hand, stable price level of kinnow will provide incentives to the producers to increase the production. Generally, agricultural commodities have high volatility especially fruits which are highly perishable compared to manufactured goods hence the price fluctuations are expected. However, the volatility of kinnow prices is below 50 percent i.e. low to medium price variation indicating normal volatility in prices of agricultural commodities. The results agree with Nayyar and Sen (1994); Chand (2001), which argued that there is evidence of a much lower degree of agricultural price variability at the national level in Indian markets, as compared to the world markets

Table 3 shows the bivariate correlation analysis of various market pairs studied. The results show that Bikaner and Ganganagar are positively correlated at a value of 0.603. Ganganagar and Jodhpur too are positively correlated at value of 0.419 indicating less strength of relationship between the market pairs. Ganganagar and Ajmer do not have any relationship according to the results. There is also a strong positive correlation of market prices of Jaipur and Ganganagar. A stronger relationship exists between Delhi and Ganganagar with a value of 0.820 which indicates each other price affect the other.

A test for a suitable lag length to be included in the co-integration test was performed, because the results of co-integration tests can be quite sensitive to lag length (Hafer and Sheehan, 1991: Hai *et al.*, 2004). The number of lags is selected by applying five different multivariate lag selection criteria: the Akaike information criterion (AIC), the Hannan-Quin information criterion (HQIC), and the Schwarz's Bayesian information criterion (SBIC), FPE and LR. A Vector Autoregression (VAR) on the differenced series was conducted and lags length of the model with the least AIC, HQIC, LR and FPE values chosen as the appropriate lag length to be included in the co-integration test (Kwasi and Kobina, 2014). Taken Ganganagar and Jaipur model as an example, the preestimation lag selection criteria indicates the average maximum lag length for the model to be used in the analysis was 1 lag i.e. 1 week. This indicates the maximum time for price to be transmitted from one kinnow market (Ganganagar) to the other (Jaipur) in the long run or to move into long run equilibrium is about one (1) week at most.

Table 4 shows the unit root testing of all the market prices to be used for market integration analysis. In this analysis the constant term is suppressed. The study first examined each variable time series for evidence of non-stationarity in order to proceed with co-integration approach. At level 0, all the major kinnow market price series in Rajasthan and also Ludhiana and Delhi were not stationary according to the Augmented Dickey Fuller (ADF) and Philips-Perron (PP) results as indicated in table 4.

Table 4: Unit Root Testing

Markets	Price Level 1(0) Constant term suppress	
	ADF Statistics CV = -1.950	PP Statistics CV = -1.950
Sri Ganganagar	-1.895	-1.895
Bikaner	-1.731	-1.731
Jodhpur	-1.005	-1.005
Ajmer	-1.350	-1.350
Alwar	-1.486	-1.486
Jaipur	-0.833	-0.833
Ludhiana	-1.419	-1.419
Delhi	-1.637	-1.637

H_o: variables are not stationary or has unit root, H_1: Variables are stationary or does not have unit root

*Significant at 5%, CV=Critical Values at 5%

NB: If the absolute value of ADF, PP, DF-GLS tau test statistics is less than their 5% critical value we accept null hypothesis. It is also when the MacKinnon approximate p-value for Z(t) is insignificant

Table 5: Unit Root testing at first difference

Markets	Price Level 1(1) Constant term suppress	
	ADF Statistics CV = -1.950	PP Statistics CV = -1.950
Sri Ganganagar	-10.178*	-14.644*
Bikaner	-9.223*	-15.443*
Jodhpur	-6.635*	-20.339*
Ajmer	-6.411*	-17.143*
Alwar	-6.085*	-17.679*
Jaipur	-6.202*	-18.836*
Ludhiana	-6.042*	-14.836*
Delhi	-6.884*	-13.589*

H_o: variables are not stationary or has unit root, H_1: Variables are stationary or does not have unit root

*Significant at 5%, CV=Critical Values at 5%

NB: If the absolute value of ADF and PP are more than their 5% critical value we reject null hypothesis. It is also when the MacKinnon approximate p-value for Z (t) is significant

The results of unit root testing of all the kinnow market price series at first difference is presented in table 5. Augmented Dickey Fuller (ADF) and Philips-Perron (PP) showed similar results as indicated above. The results show that at first difference, all the prices series which were not stationary became stationary.

Table 6: Co-integration results for market pairs

Market pairs	Trace Statistics	5% Critical Value	Rank	Remarks
Ganganagar ↔ Bikaner	3.185*	3.76	Rank 1	Co-integration
Ganganagar ↔ Delhi	2.195*	3.76	Rank 1	Co-integration
Ganganagar ↔ Alwar	13.660	15.41	Rank 0	No co-integration
Ganganagar ↔ Ajmer	7.262	15.41	Rank 0	No co-integration
Ganganagar ↔ Jodhpur	3.451*	3.76	Rank 1	Co-integration
Ganganagar ↔ Ludhiana	2.846*	3.76	Rank 1	Co-integration
Ganganagar ↔ Jaipur	0.496*	3.76	Rank 1	Co-integration
Ludhiana ↔ Delhi	3.278*	3.76	Rank 1	Co-integration
Ludhiana ↔ Jaipur	13.840*	15.41	Rank 0	No co-integration
Ludhiana ↔ Jodhpur	20.545	15.41	Rank 0	No co-integration
Ludhiana ↔ Ajmer	10.818*	15.41	Rank 0	No co-integration

Source: Author's computation, * Significance at 5% level.

At rank 0: Ho: There is no co-integration between the variables, H1: There is co-integration between the variables.

NB: We accept null hypothesis when trace statistics is less than the 5% Critical value at rank 0. At rank 1: Ho: There is (1) co-integration of the variables at rank 1, H1: There is no 1 co-integration of the variables at rank 1.

NB: We accept null hypothesis when trace statistics is less than the 5% Critical value at rank 1.

The co-integration tests results as showed in table 6 indicates Ganganagar↔Alwar Ganganagar ↔ Ajmer, Ludhiana ↔ Jaipur, Ludhiana ↔ Jodhpur, Ludhiana ↔ Ajmer mare pairs are not integrated in the long run. However, Ganganagar ↔ Bikaner, Ganganagar ↔ Delhi, Ganganagar ↔ Jodhpur, Ganganagar ↔ Ludhiana, Ganganagar ↔ Jaipur and Ludhiana ↔ Delhi are integrated in the long run. In other words, there is long run relationship between production market which is Ganganagar and the various consumption markets used in the model. This means that, most of the kinnow market prices in Rajasthan move closely together in the long run although in the short run they may drift apart, indicating high efficiency between the market pairs in the state at long run.

Commenting on the increase of marketing efficiencies in India, Bathla (2006) argued that the Government of India recognizing the growing inefficiencies in the marketing system, which may dissuade gains from trade liberalization i.e. after WTO, initiated a number of reforms in agriculture markets. To start with, it reduced tariffs below the required level for a good number of commodities and removed all quantitative barriers to agricultural imports by 2001, which led to a greater openness of markets during the nineties and early 2000 compared to the eighties, and increased the external trade. In addition, kinnow marketing is an open market of which the forces of demand and supply are the determinant of the various market prices hence ensuring high efficiencies between spatial markets.

The error correction model was used to analyse the variables that were co-integrated in the long run. The error correction model gives both short run causality and speed of adjustment towards long run. The results from the error correction model as shown in Table 7 indicates the lowest speed of adjustment towards long run equilibrium was from Ganganagar to Bikaner at rate of 0.2 percent. The highest speed of adjustment was 198 percent, running Ganganagar to Ludhiana market towards long run equilibrium. This is followed by a speed of adjustment of 184 percent running from Ganganagar to Delhi market towards along run equilibrium in a period of at most 1 week. The high speed of adjustment between Ganganagar and Delhi market shows the extent to which Ganganagar kinnow is traded in Delhi.

The speed of adjustment from Ganganagar to Jodhpur is 16.4 percent where as Ganganagar to Jaipur is 10.4 percent. The results on the speed of adjustment indicates how information run from the main production market of Ganganagar to other consuming markets when price changes.

Table 7: Vector Error Correction (VECM) Model results for the co integrated market pairs

Market Pairs	Error Correction		Short run model/Causality		Short un Causality Remarks
	P value	Error term	Prob>Chi	Direction	
Ganganagar? Bikaner	0.019	-0.002	0.012	Unidirectional	Short run
Ganganagar? Delhi	0.004	-1.848	0.001	Bidirectional	Short run
Ganganagar? Jodhpur	0.009	-0.164	0.024	Unidirectional	Short run
Ganganagar? Ludhiana	0.004	-1.980	0.001	Bidirectional	Short run
Ganganagar ? Jaipur	0.051	-0.104	0.012	Bidirectional	Short run
Ludhiana ? Delhi	0.037	-0.888	0.030	Bidirectional	Short run

Source: Author's computation, A↔B=Bidirectional, A↔B=A causes B, A←B=B causes A

Ho: No short run causality running from variable A to B

H1: Short run causality running from A to B or variable A causes changes in variable B in the short run. NB: Reject null hypothesis when the Prob> chi value is > 5%

Increased competition in the buying and selling of kinnow in Rajasthan is also a determining factor to the efficiency of kinnow markets. Ludhiana and Delhi which are the highest consuming markets in north of India are close to Rajasthan offering biggest opportunity for actors to sell in these markets apart from other markets in the country that Rajasthan kinnows are sold. Again, over the years many kinnow channels have not considered exporters to buy from farmers however farmers now have the benefit of exporters buying from them directly. These among others have increased the competition of kinnow marketing in the state hence increased in efficiency indicated by the speed of adjustment.

The error correction model also gives the short run integration of the cointegrated market pairs. The results in table 7 shows that there is short run unidirectional causality of Ganganagar → Bikaner and Ganganagar→ Jodhpur. Thus, a price change in Ganganagar will result in an instantaneous price change in kinnow price in the Bikaner and Jodhpur markets. However a price change in Bikaner or Jodhpur market cannot instantaneously affect price in Ganganagar. This could be that Bikaner and Jodhpur are not major consuming markets of kinnow though the prices are integrated in the long run.

On the other hand, Ganganagar ↔ Delhi, Ganganagar ↔ Ludhiana, Ganganagar ↔ Jaipur and Ludhiana "! Delhi have bidirectional causality in the short run. The short run causality means that a change in one of the prices of the market pairs results in an instantaneous less than 1 week based on the lag selection criteria reflection in the other market pair resulting in high efficiencies of the kinnow markets. The high bidirectional causality shows how the two markets depend on each other in terms of supply and demand of kinnow.

Table 8 indicates the results of short run causality between the non co-integrated market pairs. The test is also known as the Granger causality test of VAR model. The results shows there is no short run causality between the market pairs of Ganganagar "! Alwar and Ludhiana "! Jodhpur. Meaning, there is exists no relationship between the price changes of these markets both in the long and short run.

Table 8: Vector Autoregressive (VAR) model for the non co-integrated market pairs Granger Causality Wald Tests

Markets Pairs	Prob>F	Direction	Short run causality
Ganganagar ↔ Alwar	0.855 [ns]	—	No short run
Ganganagar →Ajmer	0.005	Unidirectional	Short run
Ludhiana → Jaipur	0.007	Unidirectional	Short run
Ludhiana ↔ Jodhpur	0.836[ns]	—	No Short run
Ludhiana → Ajmer	0.004	Unidirectional	No short run

Source: Author's computation, A↔B=Bidirectional, A→B=A causes B, A ←B=B causes A

Ho: No short run causality running from variable A to B

H1: Short run causality running from A to B or variable A causes changes in variable B in the short run

NB: Reject null hypothesis when the p value is > 5%

On the other hand, the results show a unidirectional causality of some market pairs namely Ganganagar '→ Ajmer, Ludhiana → Jaipur and Ludhiana → Ajmer. It shows a price change in Ganganagar will result in an instantaneous change in price of Ajmer but not the other way round. In the same way a price change in Ludhiana can have an instant change on Jaipur and Ajmer markets and not the other way round.

Impulse response function is a shock to both VAR and ECM models used in the analysis. Impulse responses identify the responsiveness of the dependent variable which is (endogenous variables) in the models when a shock is put to the error term. Positive shocks are shocks that affect the market prices of the markets in the consumption markets positively (i.e. a decrease in the price of kinnow in the production area market i.e. Sri Ganganagar market price)

The results in figure 1 show the impulse response function when an unexpected shock is given to market price in Ganganagar or when one positive standard deviation is given to Ganganagar there will be a response from Bikaner kinnow market price. The results shows within a period of four weeks, Bikaner kinnow prices will fall continuously up to one week and stabilize up to two weeks and fall again till third week and stabilize again when the unexpected shock is given to Ganganagar kinnow market prices. In other words, the graphs indicate that an orthogonalized shock to the average kinnow price in Ganganagar will have a permanent effect on the average kinnow price in Bikaner. According to this model, unexpected shocks that are local to the Bikaner kinnow market will also have a permanent effect on kinnow prices in Bikaner.

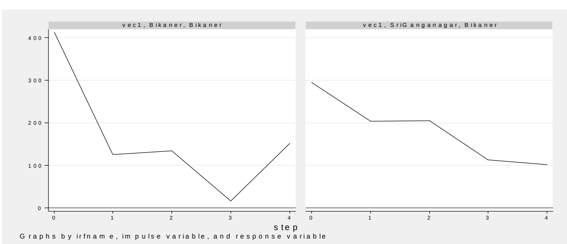

Fig. 1: Impulse response function between Ganganagar and Bikaner

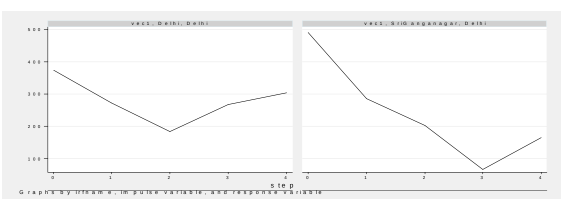

Fig. 2: Impulse response function between Ganganagar and Delhi

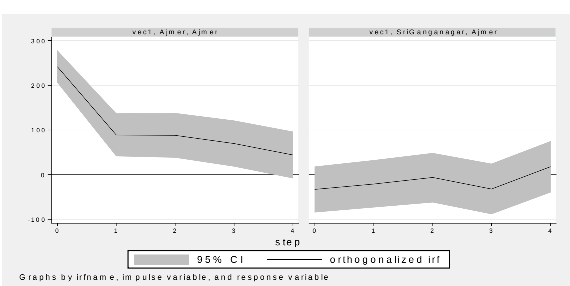

Fig. 3: Impulse response function between Ganganagar and Ajmer

Source: Authors own computation, 2015.

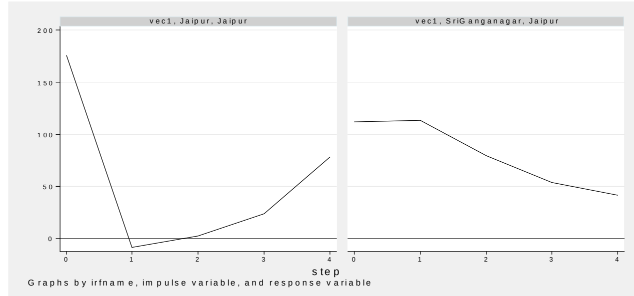

Fig. 4: Impulse response function between Ganganagar and Jaipur

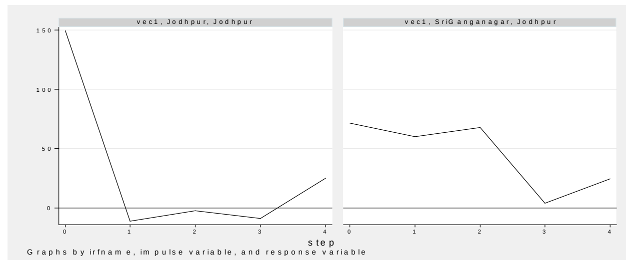

Fig. 5: Impulse response function between Ganganagar and Jodhpur

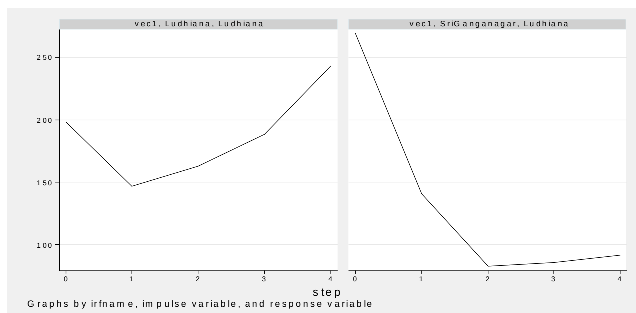

Fig. 6: Impulse response function between Ganganagar and Ludhiana

Source: Authors own computation, 2015

Figure 2 shows an orthogonalized shock or one standard deviation change in the average kinnow price in Ganganagar will have a permanent effect on the average kinnow price in Delhi. According to this model, unexpected shocks that are local to the Delhi kinnow market will also have a permanent effect on kinnow prices in Delhi.

Figure 3 shows an orthogonalized shock or one standard deviation change in the average kinnow price in Ganganagar will have a transitory effect or temporary effect on the average kinnow price in Ajmer. According to this model, unexpected shocks that are local to the Ajmer kinnow market will also have a permanent effect on kinnow prices in Ajmer.

Figure 4 shows an orthogonalized shock or one standard deviation change in the average kinnow price in Ganganagar will have a permanent effect on the average kinnow price in Jaipur. According to this model, unexpected shocks that are local to the Jaipur kinnow market will also have a permanent effect on kinnow prices in Jaipur. This is because the graph shows the effect of a shock from Ganganagar does not die out over time, hence the shock is said to be permanent. Shocks to the permanent component have long-lasting effects.

Table 9: Diagnostic Checking of the VAR and ECM models

Markets Pairs	Langrage Multiplier Test		Jarque-Bera Test
	Prob>Chi 2		Prob> Chi 2
	Lag 1	Lag 2	
Ganganagar ↔ Bikaner	0.765	0.942	0.539
Ganganagar ↔ Delhi	0.211	0.973	0.529
Ganganagar ↔ Alwar	0.511	0.674	0.419
Ganganagar ↔ Ajmer	0.536	0.743	0.085
Ganganagar ↔ Jodhpur	0.128	0.379	0.600
Ganganagar ↔ Ludhiana	0.989	0.200	0.283
Ganganagar ↔ Jaipur	0.349	0.397	0.237
Ludhiana ↔ Delhi	0.061	0.830	0.264
Ludhiana ↔ Jaipur	0.802	5.096	0.829
Ludhiana ↔ Jodhpur	0.449	0.213	0.679
Ludhiana ↔ Ajmer	0.755	0.593	0.256

Source: Author's computation

Langrange Multiplier Test: H_o: No autocorrelation H_1: There is autocorrelation

Jarque Bera Test: H_o: Residuals are normally distributed H_1: Residuals are not normally distributed

NB: Reject null hypothesis when p value is less than 5%

Figure 5 shows unexpected shocks that are local to the Jodhpur kinnow market will also have a transitory or transitory effect on kinnow prices in Jodhpur. However orthogonalized shock or one standard deviation change in the average kinnow price in Ganganagar will have a permanent effect on the average kinnow price in Jodhpur prices. This is because the graph shows the effect of a shock from Ganganagar does not die out over time, hence the shock is said to be permanent. Shocks to the permanent component have long-lasting effects.

Figure 6 shows unexpected shocks that are local to the Ludhiana kinnow market prices will also permanent effect on itself. However orthogonalized shock or one standard deviation change in the average kinnow price in Ganganagar will have a permanent effect on the average kinnow price in Ludhiana prices. This is because the graph shows the effect of a shock from Ganganagar does not die out over time or fall below the zero line, hence the shock is said to be permanent. Shocks to the permanent component have long-lasting effects.

Diagnostic tests are tests meant to 'diagnose" some problems with the models used in estimating parameters. Diagnostic checking is as important as using the model to estimate the problem. The LM test was used to analyse autocorrelation at lag order 1 and 2 in the analysis whereas the Jacque-Bera test was used to test the normality of distribution of market price residuals in the models used. The results (Table 9) show that the residuals of all the models in the analysis of market pairs are normally distributed and there is no autocorrelation in the models used. This means, the models were fit and adequate for the analysis.

Conclusion and Recommendations

The study has shown that, the mean price of kinnow in Indian Rupees (₹) per quintal from the period of 2010-2015 for the six (6) markets across Rajasthan and two (2) outside the state was lowest at ₹ 921.94 in Jodhpur market. The highest average was recorded at price of ₹ 1864.30 in Delhi market which was expected. The minimum price was recorded in Sri Ganganagar market, at price of ₹ 283.27 which was expected because it is the main production hub of kinnow in the state. Also the maximum was price recorded in Delhi market, at price of ₹ 5777.00. Coefficient of variance or variation which was used to measure the volatility of kinnow market prices indicates Jaipur market has lowest price volatility which is represented by 17.56% compared to 41.10% in Sri Ganganagar market, which has the highest. This study also explored long run and short run causality of kinnow market in Rajasthan state of India for the time period using the Johansen bivariate co-integration approach, error correction model and the unrestricted vector autoregressive model. The co-integration tests results as showed in the Table 6 indicates Ganganagar ↔ Alwar Ganganagar ↔ Ajmer, Ludhiana ↔ Jaipur, Ludhiana ↔ Jodhpur, Ludhiana ↔ Ajmer mare pairs are not integrated in the long run. However, Ganganagar ↔ Bikaner, Ganganagar ↔ Delhi, Ganganagar ↔ Jodhpur, Ganganagar ↔ Ludhiana, Ganganagar ↔ Jaipur and Ludhiana ↔ Delhi are integrated in the long run. In other words, there is long run relationship between production market which is Ganganagar and the various consumption markets used in the model. This means that, most of the kinnow market prices in Rajasthan move closely together in the long run although in the short run they may drift apart, indicating high efficiency between the market pairs in the state at long run. The results from the error correction model shows, there is short run unidirectional causality of Ganganagar → Bikaner and Ganganagar → Jodhpur. Thus, a price change in Ganganagar will result in an instantaneous price change in kinnow price in the Bikaner and Jodhpur markets. The results from the error correction model indicate the lowest speed of adjustment towards long run equilibrium was from Ganganagar to Bikaner at rate of 0.2 %. The highest speed of adjustment was 198 percent, running Ganganagar to Ludhiana market towards long run equilibrium. This is followed by a speed of adjustment of 184 % running from Ganganagar to Delhi market towards along run equilibrium in a period of at most 1 week. The high speed of adjustment between Ganganagar and Delhi market shows the extent to which Ganganagar kinnow is traded in Delhi. The speed of adjustment from Ganganagar to Jodhpur is 16.4 percent where as Ganganagar to Jaipur is 10.4 %. The results on the speed of adjustment indicates how information run from the main production market of Ganganagar to other consuming markets when price changes.

Furthermore, results of short run causality between the non co-integrated market pairs. The test is also known as the Granger causality test of VAR model. The results shows there is no short run causality between the market pairs of Ganganagar ↔ Alwar and Ludhiana ↔ Jodhpur. Meaning, there is exists no relationship between the price changes of these markets both in the long and short run. On the other hand, the results show a unidirectional causality of some market pairs namely Ganganagar → Ajmer, Ludhiana → Jaipur and Ludhiana → Ajmer. It shows a price change in Ganganagar will result in an instantaneous change in price of Ajmer but not the other way round.

The impulse response function shows that an unexpected shock in the prices of kinnow in Ganganagar will have a permanent lasting effect on prices of the various markets within a period of 4 weeks except Ajmer market prices.

Based on the results, the researchers propose the following policy recommendations. Government should continue to invest in domestic kinnow production, warehousing, processing factories and other infrastructure to be able to maintain and sustain the efficiency of the kinnow markets in Rajasthan and its marketing channels. There should be price forecasting of kinnow prices by Government so as to increase competitiveness of the kinnow marketing.

Government should also in addition to policies undertaken, create the development of kinnow or fruit or clusters or parks with best transport and infrastructure facilities (which will encourage kinnow along with other fruits crops mango) to reduce transaction costs for both farmers and other actors. Lastly, research should be conducted to determine the efficiency of kinnow markets using a higher models such Threshold autoregressive models.

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