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Study on Panel Cointegration, Regression and Causality Analysis in Papaya Markets of India

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A B S T R A C T

This paper employs the panel cointegration tests to analyse the long run relationships between papaya markets in India, using data of monthly average wholesale papaya price from January, 2001 to December, 2016. Cointegration analysis and the cointegration regression are applied along with the causality test to find the long run relationship between markets. The result indicated that there is a panel long-run equilibrium relationship among the markets. The regression coefficients of both FMOLS and DOLS indicated that Bangalore market price heavily influences the price of papaya in Chennai market with the regression coefficient value of 5.7 per cent and 5.6 per cent respectively. Both Pairwise Granger causality and Dumitrescu Hurlin Panel causality test also confirms bidirectional relationship among Bangalore market and Ahmedabad market. Bidirectional relationship was also found in Chennai and Bangalore, Bangalore and Bhopal markets. Finally, it is observed that Bangalore market price influences the price series in other market of our study. Still market integration can be improved by making up-to-date market information available to all participants.

Introduction

Marketing of horticultural crops is complex especially because of perishability, seasonality and bulkiness. There is enough evidence to show that prices of the agricultural commodities are more volatile than those of the non-farm commodities due to their low price elasticity and income elasticity, an inherently unstable agriculture production due to risk and exogenous shocks from weather. Apart from these factors, the state governments follow different policies in terms of sales tax, levies and regulations on the supply of agricultural produce from other states. The market integration can be measured in terms of the strength and speed of price transmission between markets across various regions of the country (Ghafoor *et al.*, 2009). The degree, to which consumer and producers would benefit, depends on how domestic markets are integrated with world markets and how different regional markets are integrated with each other (Varela *et al.*, 2012). There has been concern in recent years regarding the efficiency of marketing of fruits and vegetables, and that this is leading to high and fluctuating consumer prices and only a small share of the consumer rupee reaching the farmers. Although several studies have been done empirically using co-integration techniques which concern the market integration of agricultural commodities in India (Kar *et al.,* 2004; Jha *et al.,* 2005; Shenoy, 2008; Ghosh, 2011; Acharya *et al.*, 2012; Reddy *et al.*, 2012; Sekhar, 2012). The major factors influencing on price of papaya are arrivals in the market, climatic conditions during the various growth stages, price movement over the period of time, demand and supply of global as well as domestic markets, etc. In this context, price analysis was carried out to know the extent and pattern of market integration of papaya in selected markets.

Materials and Methods

The data on monthly average wholesale papaya price (in Rs. / 100 kg) in Ahmedabad, Bangalore, Bhopal and Chennai markets from January, 2001 to December, 2016 were taken from the National Horticulture Board, Government of India. The analytical techniques used in the study are described below.

Panel unit root test

We use five unit root tests to check for the integration order of each variable: Breitung (2000), Levin *et al.*, (2002), Im *et al.*, (2003), tests of Fisher using Augmented Dickey and Fuller (ADF) (1979), and Phillips and Perron (1988). While these tests are commonly termed "panel unit root" tests, theoretically, they are simply multiple-series unit root tests that have been applied to panel data structures (where the presence of cross-sections generates "multiple series" out of a single series).

$$Y_{it} = \rho_i Y_{it-1} + \delta_i X_{it} + \varepsilon_{it} \quad (1)$$

Where i = 1, 2, 3…N cross section units that is observed over periods t= 1,2,3….T_i

The Y_{it} refers to the pooled variable and the X_{it} exogenous variables in the model, ρ_i are the autoregressive coefficients and the errors ε_{it} are assumed to be mutually independent idiosyncratic disturbance. If $|\rho_i| < 1$, Y_i is said to be weakly (trend) stationary. On the other hand, if $|\rho_i| = 1$then Y_i contains a unit root. For purposes of testing, there are two natural assumptions that we can make about the ρ_i. First, one can assume that the persistence parameters are common across cross-sections so that $\rho_i = \rho$ for all i. The Levin, Lin, and Chu (LLC), Breitung, and Hadri tests all employ this assumption. Alternatively, in Im, Pesaran, and Shin (IPS), and Fisher-ADF and Fisher-PP tests allow ρ_i to vary freely across cross-sections.

Panel co-integration

Once it is found from the unit root test that the variables are stationary, i.e., they are integrated of same order, then the next step is to apply co-integration analysis to examine whether a long run co-integration relationship exists among those variables. Pedroni's (1999; 2004) method of co-integration allows for heterogeneity across individual members of the panel. It considers the following time series panel regression:

$$Y_{it} = \alpha_i + \delta_i t + \beta_{mi} X_{mit} + e_{it} \quad (2)$$

where t= 1,2,…., T, i=1,2,…, N, m=1,2,…, M; Y_{it} and X_{mit} are the observable variables with dimension of (N*T) × 1 and (N*T) × m, The parameters α_i and δ_i allow for the possibility of member specific effect and deterministic trend respectively. The slope coefficients β_i's are also permitted to vary across individuals, so that, in general, the co-integrating vectors may be heterogeneous across members of the panel and e_{it} error term. The null hypothesis of Pedroni's test is no co-integration, and the test allows for unbalanced panels, including heterogeneity in both the long-term co-integration vectors. There are seven panel co-integration statistics, first part is based on the within dimension approach, the second part is based on the between-dimension approach. The distributions of these seven statistics are all asymptotically standard normal. The panel v statistic is related to a one-sided test where large positive values reject the null hypothesis of no co-integration.

The Kao test follows the same basic approach as the Pedroni tests, but specifies cross-section specific intercepts and homogeneous coefficients on the first-stage regressors. In the bivariate case described in Kao (1999), we have

$$Y_{it} = \alpha_i + \beta_i X_{it} + e_{it} \quad (3)$$

We consider running the first stage regression equation of pedroni (equation 2), requiring the α_i to be heterogeneous, β_i to be homogeneous across cross-sections, and setting all of the trend coefficients δ_i to zero.

Combined Individual Tests (Fisher/Johansen)

Fisher (1932) derives a combined test that uses the results of the individual independent tests. Maddala and Wu (1999) use Fisher's result to propose an alternative approach to testing for co-integration in panel data by combining tests from individual cross-sections to obtain at test statistic for the full panel. p-values for Johansen's co-integration trace test and maximum eigenvalue test is based on MacKinnon-Haug-Michelis (1999) χ^2 value.

Panel long-run estimates

In the cointegrated panels, using ordinary least square (OLS) method to estimate the long-run equation leads to biased and inconsistent estimator of the parameters. OLS estimates suffer from asymptotic bias unless the regressors are strictly exogenous, so that the OLS standard errors cannot generally be used for valid inference. We estimate the long-run coefficients by using the fully modified ordinary least square (FMOLS) and dynamic ordinary least squares (DOLS) estimators. The FMOLS approach estimate has been proposed by Pedroni (1999, 2004), whereas the DOLS approach has been recommended by Kao and Chiang (2001), and Mark and Sul (2003) for the panel case. These two approaches are more powerful than the ordinary least square (OLS) approach. The advantage of the FMOLS non-parametric technique is that it corrects for both endogeneity bias and serial correlation, whereas DOLS is a parametric technique. The general form of regression equation is

$$Y_{it} = \alpha_i + \beta_i X_{it} + u_{it} \quad (4)$$

$$X_{it} = X_{it-1} + v_{it}$$

With the regressors Y_{it} is the Chennai market price at month i year t, X_{it} is 3×1 vector of market i at time t, and being integrated of same order, then co-integrated with slopes β_i.

Granger causality test

In the pair wise granger causality test, two variables are usually test together with an expectation of either these results; Uni-directional causality, Bidirectional causality and No causality.

Granger Causality is computed by running bivariate regressions, in a panel data which takes the form:

$$Y_{it} = \alpha_{0i} + \alpha_{1i} Y_{it-1} + \ldots\ldots + \alpha_{ki} Y_{it-k} + \beta_{1i} X_{it-1} + \ldots\ldots\ldots \beta_{ki} X_{it-k} + v_{it} \quad (5)$$

$$X_{it} = \alpha_{0i} + \alpha_{1i} X_{it-1} + \ldots\ldots + \alpha_{ki} X_{it-k} + \beta_{1i} Y_{it-1} + \ldots\ldots\ldots \beta_{ki} Y_{it-k} + v_{it}$$

Where t denotes the time period dimension of the panel, and i denotes the cross-sectional dimension. The different forms of panel causality test differ on the assumptions made about the homogeneity of the coefficients across cross-sections.

Stacked (Common coefficients) causality test

The stacked causality tests by Granger (1969), it treat the panel data set as one large stacked set of data without taking a lagged value of one cross section to the next cross section. This approach assumes that all coefficients are same across all cross section (common coefficient).

$$\alpha 0_i = \alpha 0_j, \alpha 1_i = \alpha 1_j, \alpha 2_i = \alpha 2_j ...., \alpha m_i = \alpha m_j \quad \forall\, i, j \quad (6)$$

$$\beta_{0i} = \beta_{0j}, \beta_{1i} = \beta_{1j}, \beta_{2i} = \beta_{2j} ...., \beta_{mi} = \beta_{mj} \quad \forall\, i, j$$

Dumitrescu-Hurlin (Heterogeneous or unequal coefficients) panel causality tests

Based on this approach given by Dumitrescu and Hurlin (2012), it allows for all coefficients to be different or what is referred to as heterogeneous across cross section. This approach takes into account two different statistics. The first statistics Wbar-statistic, takes average of the test statistics, while the Zbar-statistic shows a standard (asymptotic) normal distribution.

$$\alpha 0_i \neq \alpha 0_j, \alpha 1_i \neq \alpha 1_j, \alpha 2_i \neq \alpha 2_j ...., \alpha m_i \neq \alpha m_j \quad \forall\, i, j \quad (7)$$

$$\beta_{0i} \neq \beta_{0j}, \beta_{1i} \neq \beta_{1j}, \beta_{2i} \neq \beta_{2j} ...., \beta_{mi} \neq \beta_{mj} \quad \forall\, i, j$$

Results and Discussion

The summary statistics of monthly wholesale prices of papaya for the period January, 2001 to December, 2016 are presented in Table 1. A perusal of Table 1 reveals that the minimum values of the average price varied from Rs. 420/100 kg in Chennai market to Rs. 232/100 kg in Bangalore market, while the maximum values of the average price varied from Rs. 2535/100 kg in Bhopal market to Rs.1804/100 kg in Bangalore market during the study period. The average prices were found to be Rs.1115.99/100 kg in Ahmedabad, Rs.767.14/100 kg in Bangalore, Rs.1014.14/100 kg in Bhopal and Rs.1120.11/100 kg in Chennai. The standard deviation price was found to be maximum in the Chennai wholesale market (Rs.499.68) and minimum in Bangalore wholesale market (Rs.370.63) from January, 2001 to December, 2016.

Panel unit root test

All unit root statistics reported in Table 2 are calculated at level. The results from these unit root tests indicate that, all four tests reject the null hypothesis of non-stationary at level, with 1 per cent level of significance.

Co-integration test

One of the main objectives of this research work is to determine the long run relationship between markets.

This can be done by testing for co-integration by the Pedroni Residual Co-integration Test (1999). The panel co-integration test consists of 7 different statistics which are grouped into two parts, within dimension and between dimensions.

From the table, the first four statistics are based on pooling the residuals along the panel test (within dimension) which allows for heterogeneity across markets by putting into consideration time factor. While the second grouped statistics are based on pooling the residuals along the group test (between dimensions) of the panel. In this case it allows for heterogeneity of parameters across markets.

In Table 3 and 4 firstly we consider Pedroni (1999) heterogenous panel co-integration test results. The first four test statistics are computed by the "within" dimension (panel statistics). If the null is rejected, then markets are co-integrated. The last three test statistics are computed by the "between" dimension (group statistics). Four of seven tests (except panel-v statistic, panel rho, group rho) reject the null hypothesis (no co-integration). Hence, it can be found out that the markets are integrated in long run.

Also Table 5, the Kao's tests (1999) for the homogeneous panel co-integration result indicate that all variables used in this model are significant at the reject of the null hypothesis (no co-integration) at 1 per cent level of significance. The empirical results of panel co-integration test show that all markets have co-integration (relationship) with each other. The result of the Johansen's Fisher panel co-integration test summarizes in Table 6, Max-eigen test statistics, support the presence of a co-integrated relation among the three variables at the 1 per cent significant level whereas in case of Trace statistics only two variables are statistically significant. We can conclude from those results of panel co-integration tests, there is a panel long-run equilibrium relationship among the markets.

Therefore, considering various forms of the residual-based panel Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS) is estimated. Table 7 and 8 presents the estimates of the co-integration vectors and t-statistics.

From the above output in Table 7, it can be interpreted that about 74 per cent of variation in price of Chennai market is explained by variations in price of the markets in the study.

Table.1 Summary statistics of monthly wholesale prices for fresh delicious papaya in selected markets for the period January 2001 to December 2016

(in Rs./100kg)

MARKET	Monthly wholesale Price			
	Maximum	**Minimum**	**Mean**	**Std. Dev.**
AHMEDABAD	2500	337	1115.99	475.64
BANGALORE	1804	232	767.14	370.63
BHOPAL	2535	310	1014.14	495.89
CHENNAI	2283	420	1120.11	499.68

Table.2 The estimated summary of panel unit root test

Method	Statistic	Prob.**
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t-stat*	-3.46	0.000
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat	-2.91	0.001
ADF - Fisher Chi-square	26.48	0.000
PP - Fisher Chi-square	26.55	0.000

* t-statistic was calculated.
** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution.
All other tests assume asymptotic normality.

Table.3 Result of Pedroni residual co-integration test

	Within dimension			
GROUP	Statistics	Probability	Weighted statistics	Probability
Panel v-Statistic	1.41	0.07	1.15	0.12
Panel rho-Statistic	-1.17	0.11	-1.29	0.09
Panel PP-Statistic	-7.86	0.00	-8.55	0.00
Panel ADF-Statistic	-7.51	0.00	-8.27	0.00

Table.4 Result of Pedroni residual co-integration test

	Between dimension	
GROUP	Statistics	Probability
Group rho-Statistic	0.045	0.51
Group PP-Statistic	-10.14	0.00
Group ADF-Statistic	-10.19	0.00

Table.5 Kao Residual co-integration test

	t-Statistic	Prob.
ADF	-9.54	0.00

The ADF is the residual-based. The null hypothesis is no co-integration.
* Indicate that the estimated parameters are significant at the 1% level.

Table.6 Johansen Fisher panel co-integration test

Unrestricted Co-integration Rank Test (Trace and Maximum Eigenvalue)				
Hypothesized No. of CE(s)	**Fisher Statistics [a] (from trace test)**	**Prob.**	**Fisher Statistics [a] (from max-eigen test)**	**Prob.**
None	16.64	0.863	16.64	0.863
At most 1	8.31	0.998	118.8	0.000
At most 2	204.0	0.000	204	0.000
At most 3	3161	0.000	3161	0.000

[a] Probabilities are computed using asymptotic Chi-square distribution

Table.7 Panel Fully Modified Least Squares (FMOLS)

Variables	**Coefficient**	**Std. Error**	**t-Statistic**	**Probability**
AHMEDABAD	0.211796	0.065396	3.238681	0.0015
BANGALORE	0.572007	0.085119	6.720108	0.0000
BHOPAL	0.512556	0.059173	8.661986	0.0000
R-squared	0.740282	Mean dependent var		1148.875
Adjusted R-squared	0.718245	S.D. dependent var		502.7125
S.E. of regression	266.8429	Sum squared resid		11748846

Table.8 Panel Dynamic Least Squares (DOLS)

Variables	Coefficient	Std. Error	t-Statistic	Probability
AHMEDABAD	0.227855	0.086785	2.625499	0.0097
BANGALORE	0.561993	0.127697	4.400991	0.0000
BHOPAL	0.458382	0.075837	6.044276	0.0000
R-squared	0.835399	Mean dependent var		1148.875
Adjusted R-squared	0.771600	S.D. dependent var		502.7125
S.E. of regression	240.2523	Sum squared resid		7446029.

Table.9 Pairwise granger causality in markets

Null Hypothesis	F-Statistic	Prob.	Remarks
BANGALORE does not Granger Cause AHMEDABAD	9.18411	0.0002	Bidirectional
AHMEDABAD does not Granger Cause BANGALORE	8.67026	0.0003	
BHOPAL does not Granger Cause AHMEDABAD	3.88892	0.0224	Unidirectional
AHMEDABAD does not Granger Cause BHOPAL	13.9248	3.E-06	
CHENNAI does not Granger Cause AHMEDABAD	2.20108	0.1140	Unidirectional
AHMEDABAD does not Granger Cause CHENNAI	15.0452	1.E-06	
BHOPAL does not Granger Cause BANGALORE	1.40128	0.2492	Unidirectional
BANGALORE does not Granger Cause BHOPAL	16.0084	4.E-07	
CHENNAI does not Granger Cause BANGALORE	7.06999	0.0011	Bidirectional
BANGALORE does not Granger Cause CHENNAI	21.4858	5.E-09	
CHENNAI does not Granger Cause BHOPAL	17.1223	2.E-07	Unidirectional
BHOPAL does not Granger Cause CHENNAI	0.07263	0.9300	

Table.10 Pairwise Dumitrescu Hurlin panel causality in markets

Null Hypothesis:	W-Stat.	Z bar-Stat.	Prob.
BANGALORE does not homogeneously cause AHMEDABAD	6.19073	3.63416	0.0003
AHMEDABAD does not homogeneously cause BANGALORE	4.66255	2.09971	0.0358
BHOPAL does not homogeneously cause AHMEDABAD	2.62535	0.05414	0.9568
AHMEDABAD does not homogeneously cause BHOPAL	4.83804	2.27592	0.0229
CHENNAI does not homogeneously cause AHMEDABAD	1.74277	-0.83206	0.4054
AHMEDABAD does not homogeneously cause CHENNAI	3.92086	1.35498	0.1754
BHOPAL does not homogeneously cause BANGALORE	4.95073	2.38907	0.0169
BANGALORE does not homogeneously cause BHOPAL	5.91227	3.35456	0.0008
CHENNAI does not homogeneously cause BANGALORE	2.91212	0.34209	0.7323
BANGALORE does not homogeneously cause CHENNAI	6.56154	4.00650	6.E-05
CHENNAI does not homogeneously cause BHOPAL	6.73009	4.17574	3.E-05
BHOPAL does not homogeneously cause CHENNAI	1.56088	-1.01470	0.3102

The entire market coefficient is statistically significant at 99 per cent confidence level and an increase of 10% in price of papaya at Bangalore Market is likely to increase the price in Chennai market by 5.7 per cent. Similarly in case of Bhopal and Ahmedabad markets the percentage was found to be 5.1 per cent and 2.1 per cent respectively.

In Table 8, panel DOLS result indicates that 83 per cent of variation in Chennai market price is explained by variations in other three markets. The Bangalore market coefficient is statistically significant and an increase in price by 10 per cent will lead to increase by 5.6 per cent.

At 99 per cent confidence level, the other two markets are observed to be a statistically significant with zero p-value corroborates this observation. The coefficients were 4.5 per cent and 2.2 per cent for Bhopal and Ahmedabad markets respectively.

Pairwise granger causality test

From Table 9 and 10 using the selected lag 2 by Schwarz information criteria SIC, we obtain the F-statistics, Wbar-statistic and Zbar statistics which permits for checking whether changes in one rice series affect another price series.

In the table, based on the stacked common coefficient causality test we have estimated pairwise causality of domestic papaya markets in India. Table 9 gives the results of the Granger causality test which show that, in four cases, i.e., Chennai, Bhopal, Ahmedabad, Bangalore there exists Unidirectional causality.

In these cases Bhopal does not Granger Cause Chennai, Bangalore and Ahmedabad it means that any price change in Bhopal market does not affect the rest of the markets of our study while Chennai does not Granger Cause Ahmedabad alone.

The matrix representation of the information contained in Table 10.

	Ahmedabad	Bangalore	Bhopal	Chennai
Ahmedabad	0	→	→	0
Bangalore	→	0	→	→
Bhopal	0	→	0	0
Chennai	0	0	→	0

Where, →implies that there is significant causality running from the row-variables to the column-variables and 0 implies that there is no significant causality running from the row-variables to the column-variables.

The results provided in Table 10 tend to indicate unidirectional causality between the Bangalore and Chennai, Chennai and Bhopal respectively. The results of the Dumitrescu-Hurlin Panel Causality test across the markets under study. At 5 per cent level of significance, it is evident to reject the null that Ahmedabad does not homogeneously cause Bangalore. This tends to imply that market price at Ahmedabad can be used to predict the price in Bangalore market in the long run. Similarly, there is evidence to reject the null that Ahmedabad does not homogenously cause Bhopal and statistically significant at 5 per cent level of significance. There is also strong evidence to reject at 1 per cent level of significance, the null that Bangalore market price does not homogeneously cause the Ahmedabad market price.

The results of panel unit root test indicate that all the four markets are stationary at levels. The results of the different panel co-integration tests support that there is a panel long-run equilibrium relationship among the markets in the long run. The results of panel FMOLS and DOLS show that a 10 per cent increase price of papaya in Bangalore market increases the price in Chennai by 5.7 per cent and 5.6 per cent respectively, long-term price change in Bhopal and Ahmedabad will cause change in Chennai price 5.1 per cent, 4.5 per cent and 2.1 per cent, 2.2 per cent respectively. Pairwise Granger causality and Dumitrescu Hurlin Panel causality test also confirms the causal relationship is bidirectional in case of Bangalore and Ahmedabad in both the causality test, along with Chennai and Bangalore, Bangalore and Bhopal markets. Thus, the market integration can be improved by making up-to-date market information available to all participants through various means, including a good market information systems, internet and good telecommunications facilities at the markets. Market infrastructure can be improved through storage (go-down) facilities, cold storages, loading and weighing facilities. Improvement in the road network, and cold-chain facilities are also of substantial importance.

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