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Integration of Maize Markets in India: A Vector Error Correction Approach

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ABSTRACT

This paper examines whether the maize markets have become spatially integrated or not. Wholesale weekly prices of maize collected from five markets during the period of March, 2010 to April, 2014 were used to test the degree of market integration in India. The error correction technique was employed in the determination of the degree of market integration between the selected states using a four test procedures viz: Augumented Dickey Fuller test to detect for the presence of unit root in the series, Johansen co-integration test for the long run equilibrium relationship among the variables, Vector Eror Correction Model test (VECM) to capture short-run and long-run changes in the price movements and Granger Casualty test to reflect the direction of influence between prices. The Johansen co-integration test indicated that there were about four co-integrating vectors implying that maize markets in India during the study period were moderately linked together and therefore, the long-run equilibrium was stable. The short-run market integration as measured by the magnitude of market interdependence and the speed of price transmission between the markets had been weak. The causality test results indicated that though the maize price in selected state markets drifted apart in the short run, there was smooth transmission of price signals and marketing information in the long run.

Key Words: Maize, Co integration, Market integration, India, VECM
JEL Classification: C22, C32, O53, Q11

INTRODUCTION

Spatial and temporal market integration is an indicator of the efficient functioning of agricultural markets. India has been implementing agricultural liberalization policies since the early 1990s. It has been argued that such market reforms are required for achieving efficient agricultural markets and hence an efficient agricultural production system. Jha and Srinivasan (2000) have argued that such liberalisation is required for achieving allocative efficiency and long-term growth in agriculture. Until agricultural markets are integrated, producers and consumers will not realize the potential gains from liberalization. The term 'spatial market integration' refers to a situation in which the prices of a commodity in spatially separated markets move together and the price signals and information are transmitted smoothly across the markets. Hence, spatial market performance may be evaluated in

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terms of the relationship between the prices of spatially separated markets, and spatial price behaviour in regional markets may be used as a measure of overall market performance.

In this paper an attempt has been made to examine the existence of integration among the major maize markets in India. The maize production during 2013-14 was 24.35 million tons. Punjab has a vast potential in most of its area, to adopt maize as an alternative of paddy crop, which requires a lot of water. It is pertinent to mention here that Punjab was traditionally a maize growing state which changed its status to paddy cultivation during the green revolution era. Maize is the third most important *Kharif* season crop after paddy and cotton in Punjab. The area under maize in Punjab has declined from 1.65 lakh hectares in 2000-01 to 1.30 lakh hectares in 2013-14.With an average productivity of 38.98 quintals per hectare, the total maize production in the state was 5.07 lakh tons during 2013-14 (Anonymous 2014).

There are several studies that have dealt with the measurement of market co integration, of agricultural commodity. Silumbu (1992) used monthly wholesale prices to test for the spatial and inter-temporal market integration of maize markets in Malawi and found that the integration of urban markets had increased slightly even under partial liberalization. Goletti and Babu (1994) used different measures of integration and monthly retail maize prices for eight regional markets in Malawi. They concluded that the liberalization of the maize market had increased market integration. Goletti *et al.* (1995) used weekly wholesale prices of rice to test the structural determinants of market integration in the rice market in Bangladesh and concluded that the degree of rice market integration in Bangladesh is moderate. Baulch *et al.* (1998) studied the spatial integration and pricing efficiency of the private sector grain trade in Bangladesh and provided econometric evidence suggesting that wholesale markets for rice are in fact well integrated, except for periods of major shortages in domestic production (such as those just after the 1997/98 and 1998/99 *Aman* harvests). Getnet *et al.* (2005) studied the spatial equilibrium of grain markets in Ethiopia by using the co-integration technique and provided evidence of domestic market integration. The present study has been taken to analyze the market integration between the maize markets in India.

METHODOLOGY

The study is based on time series data. Data for the study were obtained from secondary sources. Time series data on the weekly wholesale prices of maize required for the study were collected from the office of Market Committees, www.agmarknet.com and website of selected markets for period from April 2010 to March 2014. Five markets were selected randomly throughout India, viz., Hoshiarpur and SBS Nagar market (Punjab), Bengaluru market (Karnataka), Vijayanagaram market (Andhra Pradesh) and Ahmednagar market (Maharastra).

Augmented Dickey Fuller Test

While dealing with time series data, the first step was to check whether the underlying time series was stationary or not. To check the unit root in data the Augemented Dickey-Fuller (ADF) test was used .The autoregressive formulation of the ADF test with a drift term is given by equation (1):

$$\Delta p_{it} = a_0 + \gamma P_{it-1} + \sum_{i=2}^{n} \beta_i \Delta p_{it-j+1} + \varepsilon_t \quad \text{..........(1)}$$

where p_{it} is the price in market i at the time t and is the intercept or drift term.The joint hypothesis to check the presence of unit root is: = using f_1 statistics. Failure of the rejection of null hypothesis means that the series is non-stationary.

Co-Integration Analysis

The co-integration analysis reflects the long run movement of price series although, they may drift in short run. For co-integration analysis, the Johansen's (1988) maximum likelihood estimator was chosen over the Engle and Granger (1987) two step procedure.The Johansen procedure is a multivariate generalization of the Dickey-Fuller test and formulation is as follows:

$$\Delta p_{it} = A_1 p_{it-1} - p_{it-1} + \varepsilon_t \quad \text{.........(2)}$$

$$\Delta p_{it} = (A_1 - I) p_{it-1} + \varepsilon_t \quad \text{.........(3)}$$

$$\Delta p_{it} = \pi p_{it-1} + \varepsilon_t \quad \text{..............(4)}$$

where, p_{it} and ε_t are (n´1) vectors; A_1 is an (n´n) matrix of parameters;I is an (n´n) identity matrix and À is the $(A_1 - 1)$ matrix.

Trace test was used to determine the presence of co-integrating relationship between the price series. Using the estimates of the characterstic roots,the test for the number of characteristic roots that are insignificantly diifferent from unity was conducted using the following statistics:

$$\lambda_{trace}(r) = -T \sum_{j=r+1}^{n} \ln\left(1-\hat{\lambda}_j\right) \quad \text{...............(5)}$$

where,

$\hat{\lambda}_j$ denotes the estimated values of the characteristic roots (eigen value) obtained from the estimated π matrix; and T is the number of usable observations.The Eigen values representing the strength of the correlation between the first difference and error-correction.

Granger Causality Test

The co-integration tests performed indicate the existence of long run relationship among the wholesale prices of selected maize markets. When a co-integration relationship is observed among for variables, Granger causality test (Granger,1969) can be used to analyze the direction of this co-movement relationship, because the direction of the relationship is equally important. Whether market p_1 Granger causes market p_2 or vice versa was checked using equation (6)

$$p_{1t} = c + \sum_{j}^{n} \left(\phi p_{1t-j} + \delta_j p_{2t-j}\right) + \varepsilon_t \quad \text{...........(6)}$$

A simple test of the joint significance of δ_j was used to check the Granger causality, i.e. $H_0: \delta_1 = \delta_2 = \dots \dots \delta_n = 0$

Vector Error Correction Model

Vector Error Correction Model (VECM) to find the short-term disturbance and the adjustment mechanism to estimate the speed of adjustment.The VECM explains the difference in y_t and y_{t-1} (i.e.Δy_t) by equation (7):

$$\Delta y_t = a + \mu(y_{t-1} - \beta x_{t-1}) + \sum_{i=0}^{i-1} \delta_i \Delta x_{t-i} + \sum_{i=1}^{i-1} \gamma_i \Delta y_{t-i} \quad \text{...............(7)}$$

It includes the lagged differences in both x and y, which have a more immediate impact on the value of Dy_t. In explaining changes in a variable, the ECM accounts for its long run relationship with other variable. The coefficient of error-correction

TABLE 1: ADF UNIT ROOT TEST ON WHOLESALE PRICES OF SELECTED MAIZE MARKETS

Markets	At Level	Stationarity	At First difference	Stationarity	Critical values (at 1% level)
Hoshiarpur	-2.978605	Non-stationary	-16.26267	Stationary	
SBS Nagar	-3.153475	-do-	-18.89196	-do-	
Bengaluru	-2.585512	-do-	-16.42697	-do-	-4.003005*
Vijayanagaram	-3.325581	-do-	-13.94975	-do-	
Ahmednagar	-3.393945	-do-	-12.94556	-do-	

* Significant at 1 per cent level of significance.

term indicates the speed at which the series returns to equilibrium. If it is less than zero, the series converge to long-run equilibrium and if it is positive and zero, the series diverges from equilibrium.

RESULTS AND DISCUSSION

The integration tests elaborated above were carried out on log weekly wholesale prices of different markets in India. These tests have been used to study the integration of markets. To avoid spurious results, there was a need to check whether the variables were stationary or not. Therefore, it was necessary to examine time-series properties of the Variables. Further, to establish the long-run equilibrium relation among the price series, it was necessary to co-integrate them. Co-integration among the variables, in turn, required checking the order of integration among variables and variables cannot be integrated in the presence of unit root, the same can be examined through conducting a stationarity test. The price movement, volatility within the market and integration between market were studied with time series data collected from market committee and AGMARKNET web site. Augmented Dickey-Fuller test (ADF) was applied to check whether the price series of maize crop are stationary in their level, followed by their first difference.

Stationarity of Series

The evaluation of market efficiency by co-integration analysis recognised that the time series of prices for various markets were usually non-stationary variables (Shen and Wang, 1990; Fortenbery and Zapata 1993, Wang and Ke, 2005, Wani *et al.*, 2015) and if these series were found to be non-stationary then it becomes necessary to test them for co-integration, which was a pre condition for market efficiency and un-biasness (Kellard *et al,* 1999).

As a prerequisite to conducting the co-integration tests, univariate time-series properties of the data was evaluated to see whether all the prices were non-stationary and integrated of the same order or not. The Augmented Dickey Fuller based unit root test procedure was used to check whether the price series of maize were stationary or not. It was clear from the Table 1 that in the case of wholesale prices of maize in levels, the ADF test did not reject the unit root hypothesis at five per cent level during the periods. In case of the first difference of the series, the hypothesis was, however, rejected in the periods mostly at the one per cent level. Thus, all the five price series at crop were stationary at the first difference level.

Co-integration Test

Based on the Johansen multiple co-integration procedure, co-integration between the markets was analyzed using E-Views software. Both the Maximum Eigen value test and trace test results indicated the presence of four co-integrating

TABLE 2 : RESULTS OF JOHANSEN CO-INTEGRATION ANALYSIS

Hypothesized No. of CE (S)	Eigenvalue	Trace Statistic	0.05 value	Prob**
None *	0.184464	122.6659	88.8038	0
At most 1 *	0.129937	82.29181	63.8761	0.0007
At most 2 *	0.107347	54.73237	42.91525	0.0022
At most 3 *	0.098972	32.24793	25.87211	0.007
At most 4	0.056963	11.6126	12.51798	0.0705

Trace test indicates 4 cointegrating eqn(s) at the 5 per cent level of significance.
* denotes rejection of the hypothesis at the 5 per cent level of significance.

vectors at the five per cent significance level. This implied that all the five markets were in fact cointegrated and had a common sharing information on price changes in the long run. The above empirical evidence suggested that all the markets exhibited a long run relationship .The results are presented in Table 2.

Causality in Various Markets

The causal relationship between the prices series in major maize markets were approached through Granger Causality technique. The results of the analysis showing the relationship between major maize markets revealed (Table 3) that the Hoshiarpur market price had depicted a unidirectional causality on the prices of SBS Nagar and Bengaluru, except no causality between Hoshiarpur and Vijayanagaram, Hoshiarpur and Ahmednagar. SBS Nagar market price had shown a unidirectional influence on the price of Bengaluru, except no causality between SBS Nagar and Hoshiarpur, SBS Nagar and Vijayanagaram, SBS Nagar and Ahmednagar. Bengaluru market price had shown a bi directional influence on the price of Ahmednagar, except no causality between Bengaluru and Hoshiarpur, Bengaluru and SBS Nagar Bengaluru and Vijayanagaram. Vijayanagaram market price had shown unidirectional influence on the price of Ahmednagar, except no causality between Vijayanagaram and Hoshiarpur, Vijayanagaram and SBS Nagar.

Vijayanagaram and Bengaluru. Ahmednagar market price has shown a bidirectional influence on the price of Bengaluru,except no causality between Ahmednagar and Hoshiarpur, Ahmednagar and SBS Nagar, Ahmednagar and Vijayanagaram.

Speed of Adjustments in Long run Equilibrium

Since the maize markets were integrated in the long run, it is important to study the short run and long run equilibrium among the markets. Hence Vector Error Correction Model (VECM) was employed to know the speed of adjustments among the markets for long run equilibrium and results of the same presented in Table 5.

The coefficient of the error correction term indicates the speed of convergence to the long run growth path as a result of a

TABLE 3 : RESULTS OF PAIR WISE GRANGER CAUSALITY TESTS IN DIFFERENT MARKETS

Markets	Hoshiarpur	Nawanshahar	Banglore	Vijayanagaram	Ahmednagar
Hoshiarpur	1	?	?	x	x
SBS Nagar	x	1	?	x	x
Bengaluru	x	x	1	x	?
Vijayanagaram	x	x	x	1	?
Ahmednagar	x	x	?	x	1

Note: ? : Bidirectional, ? : Unidirectional and x: No causality.

TABLE 5 : RESULTS OF VECTOR ERROR CORRECTION MODEL WITH FOUR LAG PERIODS IN DIFFERENT MARKETS

Error Correction:	D (Hoshiarpur)	D (SBS Nagar)	D (Bengaluru)	D (Vijay - Anagaram)	D (Ahmed- nagar)
CointEquations	-0.012899	-0.000225	0.055702	0.017947	-0.062757
	(0.02350)	(0.02979)	(0.01561)	(0.00987)	(0.01442)
	[-0.54880]	[-0.00756]	[3.56838]	[1.81915]	[-4.35314]
D(SBS Nagar(-1)	-0.106482	0.090997	-0.124408	-0.039442	0.110629
	(0.07487)	(0.09490)	(0.04972)	(0.03143)	(0.04592)
	[-1.42231]	[0.95887]	[-2.50213]	[-1.25510]	[2.40918]
D(SBS Nagar(-2)	0.003162	0.109486	-0.041266	-0.041822	0.070707
	(0.07752)	(0.09827)	(0.05149)	(0.03254)	(0.04755)
	[0.04079]	[1.11415]	[-0.80151]	[-1.28523]	[1.48703]
D(SBS Nagar(-3)	0.166463	0.480121	-0.084209	0.003741	-0.040680
	(0.07556)	(0.09578)	(0.05018)	(0.03172)	(0.04634)
	[2.20315]	[5.01292]	[-1.67815]	[0.11796]	[-0.87779]
D(SBS Nagar (-1)	-0.042194	-0.303853	-0.051994	-0.008721	-0.036888
	(0.05714)	(0.07244)	(0.03795)	(0.02399)	(0.03505)
	[-0.73839]	[-4.19481]	[-1.37003]	[-0.36358]	[-1.05244]
D(SBS Nagar (-2)	-0.012046	-0.059349	-0.032887	0.013855	-0.027121
	(0.05843)	(0.07407)	(0.03881)	(0.02453)	(0.03584)
	[-0.20614]	[-0.80125]	[-0.84745]	[0.56487]	[-0.75671]
D(SBS Nagar (-3)	-0.010028	0.007039	-0.053428	0.029725	0.003982
	(0.05524)	(0.07003)	(0.03669)	(0.02319)	(0.03389)
	[-0.18152]	[0.10052]	[-1.45619]	[1.28184]	[0.11750]
D(Bengaluru(-1)	0.089700	-0.176656	-0.132664	-0.028539	-0.026440
	(0.10740)	(0.13614)	(0.07133)	(0.04508)	(0.06588)
	[0.83519]	[-1.29758]	[-1.85990]	[-0.63306]	[-0.40136]
D(Bengaluru(-2)	0.019742	-0.127718	-0.140906	0.009312	0.077313
	(0.10568)	(0.13396)	(0.07019)	(0.04436)	(0.06482)
	[0.18681]	[-0.95341]	[-2.00762]	[0.20991]	[1.19273]
D(Bengaluru(-3)	-0.295455	0.016501	0.068202	-0.016756	0.039477
	(0.10273)	(0.13022)	(0.06823)	(0.04312)	(0.06301)
	[-2.87597]	[0.12672]	[0.99962]	[-0.38858]	[0.62650]
D(Vijayanagaram(-1)	0.265506	0.028405	0.215949	0.018074	-0.051563
	(0.17395)	(0.22050)	(0.11553)	(0.07302)	(0.10670)
	[1.52630]	[0.12882]	[1.86923]	[0.24754]	[-0.48327]
D(Vijayanagaram(-2)	-0.099402	-0.023705	0.050568	0.088272	-0.159533
	(0.17569)	(0.22271)	(0.11668)	(0.07375)	(0.10776)
	[-0.56578]	[-0.10644]	[0.43339]	[1.19697]	[-1.48042]
D(Vijayanagaram(-3)	-0.121595	-0.054019	0.092180	0.075323	0.050360
	(0.17637)	(0.22357)	(0.11714)	(0.07403)	(0.10818)
	[-0.68942]	[-0.24162]	[0.78695]	[1.01743]	[0.46552]
D(Ahmednagar(-1)	0.086529	-0.007201	0.034089	-0.061745	0.227565
	(0.12142)	(0.15391)	(0.08064)	(0.05097)	(0.07447)
	[0.71264]	[-0.04679]	[0.42274]	[-1.21149]	[3.05561]
D(Ahmednagar(-2)	0.077113	0.004930	0.132835	0.024860	-0.001307
	(0.12142)	(0.15391)	(0.08064)	(0.05097)	(0.07447)
	[0.63510]	[0.03203]	[1.64728]	[0.48777]	[-0.01755]
D(Ahmednagar(-3)	-0.122100	-0.126066	0.027622	-0.012433	0.075675
	(0.12192)	(0.15455)	(0.08097)	(0.05118)	(0.07478)
	[-1.00145]	[-0.81569]	[0.34112]	[-0.24294]	[1.01192]
C	2.087142	2.280837	1.419029	2.419720	2.129661
	(4.21595)	(5.34416)	(2.79995)	(1.76965)	(2.58590)
	[0.49506]	[0.42679]	[0.50680]	[1.36734]	[0.82357]

Note: D is the difference, ln is the natural logarithm,-C is the constant and (-1),(-2) and (-3) indicate number of lags.

shock in their price. The coefficients show how quickly variables return back to equilibrium. The Table 5 clearly shows that the co-integration equation of error correction mechanism is significant in all the five markets. It is revealed from the analysis that, any disturbance in price will get corrected in about 10 hours in Bengaluru around 11 hours in Ahmednagar. In all the selected markets, the prices were influenced by their own weekly lags for long run equilibrium. In addition, in the long run the price changes in Hoshiarpur market, the prices were influenced to the extent of 29 per cent by one week lag price of Bengaluru. In the long run the price changes in Bengaluru market were influenced to the extent of 12 per cent by one week back prices of Hoshiarpur market. In the long run the price changes in Ahmednagar market were influenced to the extent of 11 per cent by one week back prices of Hoshiarpur market.

CONCLUSION

Using weekly wholesale maize price data for the period April, 2010 to March, 2014 from five markets in India, this study examined the extent of market integration. The overall results of the market integration analysis in India, indicated that, although, the five markets in India were co-integrated-meaning that they had a stable long run relationship. These markets were also integrated in the short run. The results from trace statistics show that there were four co-integrating vectors and four common trends, which suggested that maize markets were stationary in four directions and non-stationary in four directions. Granger-causality results indicated that Hoshiarpur market price had depicted a unidirectional causality on the prices of SBS Nagar. SBS Nagar market price had shown a uni-directional influence on the price of Bengaluru. Bengaluru market price had shown a bi-directional influence on the price of Ahmednagar. Vijayanagaram market price has shown uni-directional influence on the price of Ahmednagar. Ahmednagar market price had shown a bi-directional influence on the price of Bengaluru. The short-run results indicated that these maize markets were not well integrated while long-run integration was evident, suggesting that the markets did eventually move together in the long term. The speed of adjustment appeared to be the inverse of distance and directly related with ease of transport. The policy implications of these resulted that structural rigidity resulting from poor infrastructure and insufficient transportation networks hamperd the easy flow of information between markets and therefore, the integration of markets in the short run. Thus, in order for maize surplus regional markets to be better integrated with deficit regions, the government should invest in better transportation and infrastructure facilities.

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