Agricultural Economics Research Review
Vol. 28 (No.1) January-June 2015 pp 179-187
DOI: 10.5958/0974-0279.2015.00016.6

Research Note

Integration of Wheat Markets in Maharashtra

Suvarna L. Mahalle[a*], Siddharth Shastri[b] and Shiv Kumar[c]

[a]NASF, Indian Council of Agricultural Research, New Delhi-110 012
[b]Department of Economics, Banasthali University, Banasthali, Rajasthan
[c]IPTM UNIT, Indian Council of Agricultural Research, New Delhi-110 012

Abstract

This paper has examined the market integration of wheat in Maharashtra. Both market arrivals and prices of wheat have depicted increasing trends in almost all the selected markets of Maharashtra. The seasonality in arrivals of wheat has been found higher than the seasonality in market prices, indicating a rise in market instability. Out of the seven, four markets have been found spatially integrated. Some market pairs have shown bidirectional causality, while others have depicted unidirectional causality. Almost all the selected wheat markets have shown long-run equilibrium relationship and existence of co-integration among them. The strengthening of physical infrastructure, use of information and communication technology and well-defined transparent agricultural policy/market measures in the state will help in the development of single uniform economic market in the region, in particular and country in general.

Key words: Wheat, spatial integration, market integration, seasonality, co-integration, Maharashtra

JEL Classification: C22, C32, O53, Q11

Introduction

The spatial price relationships have been widely used to study market performance. The efficient functioning of markets provides profitable prices to the producers and fair prices to the consumers. Market integration and price transmission, in the case of a large producing and consuming country like India, depend on the geographical dispersion or concentration of production. While consumers are spread throughout the country, the production and marketed surplus are less spread-out, particularly for wheat. Apart from measures or incentives to increase food production (through technology, modern inputs, irrigation expansion, and infrastructure development), several polices too have impacts on market environment and their impacts are trailed over varying rates. The government intervention in the form of policies in market, viz. announcement of minimum support prices (MSPs) and purchase of wheat grain at these prices, in the event of market prices falling below these levels; maintenance of food buffers for food security and price stability; and distribution of wheat to the consumers, particularly to the vulnerable sections of the society, at affordable (subsidized) prices; regulation of traders' marketing practices through *inter alia* imposition of stocking limits and levies; and lastly regulation of imports and exports through canalization, licensing, imposition of trade tariffs, and minimum export prices (MEPs), with a view to maintain supplies and price stability in the market (Acharya *et al.*, 2012), generate market sentiments among stakeholders that are ultimately reflected in wheat price formation in the market.

The state of Maharashtra was selected to study market integration because it accounts for 2.82 per cent of wheat area and 1.38 per cent of wheat production in the country. Analysis of the trends and seasonality in arrivals and prices of wheat markets and ascertaining

* Author for correspondence
Email: suvarna.econ@gmail.com

the extent and pattern of spatial integration in wheat markets would provide an insight into the dynamics of market integration. The study will provide an insight on the efficiency of marketing system in state and will help the policymakers and planners in identification of the groups of integrated markets to decide whether government should intervene in the wheat markets or not.

Materials and Methods

The market behaviour is analyzed by observing the trends and relationships between arrivals of a commodity and the resultant wholesale prices, whereas the market conduct is assessed by using Johansen Co-integration methodology. The monthly data on market arrivals and wholesale prices of wheat were collected for the period 1997 - 2011 from the Maharashtra State Agricultural Marketing Board (MSAMB), Pune; Agricultural Marketing Information Network-AGMARKNET (website: http://www. agmarknet. nic.in); and the Agriculture Produce Market Committees (APMCs) of Nagpur, Aurangabad, Akluj, Washim, Yeola, Shrirampur and Akole, which are the major markets for wheat in Maharashtra.

Analytical Techniques

To measure seasonal variations in prices and arrivals, seasonal indices were calculated using twelve months ratio to moving average method. The seasonal indices were computed in such a way that their sum became 1200. This was done by working out correction factor and multiplying the averages for each month by this correction factor. The correction factor (K) was worked out as follows:

K = 1200/S, where, S is the sum of seasonal indices.

The extent of seasonal price variation was estimated using intra year price rise (IPR), coefficient of average seasonal price variation (ASPV) and coefficient of variation (CV) as follows:

$$IPR = \left[\frac{HSPI - LSPI}{LSPI}\right] \times 100 \quad \text{...(1)}$$

and

$$ASPV = \left[\frac{HSPI - LSPI}{(HSPI + LSPI)/2}\right] \times 100 \quad \text{...(2)}$$

where, *HSPI* is the highest seasonal price index, and *LSPI* is the lowest seasonal price index.

In order to examine the nature of relationship between market arrivals and prices, the model used was:

$$P_t = a + bP_{t-1} + cY_t + U_t \quad \text{...(3)}$$

where, P_t is the current price (₹ /quintal) of wheat in period t; Y_t is the arrival (quintals) of wheat in period t; P_{t-1} is the lagged price of wheat; a, b and c are the parameters to be estimated, and U_t is the error-term.

Augmented Dickey Fuller Test

A comprehensive review of approaches for analysing the market integration and price transmission by Rapsomanikis *et al.* (2006) was helpful in sharpening the methodology used for this study. The Augmented Dickey-Fuller test (ADF) is the test for the unit root in a time series sample. The autoregressive formulation of the ADF test with a drift term is given by Equation (4):

$$\Delta p_{it} = a_0 + \gamma\, p_{it-1} + \sum_{j=2}^{n} \beta_i \Delta p_{it-j+1} + \varepsilon_t \quad \text{...(4)}$$

where, p_{it} is the price in market i at the time t, $\Delta p_{it} = (p_{it} - p_{it-1})$ and a_0 is the intercept or drift term. The joint hypothesis to check the presence of unit root is: $H_0 : \gamma = a_0 = 0$ using ϕ_1 statistic. Failure of the rejection of null hypothesis means that the series is non-stationary.

Johansen's Co-integration Test

For co-integration analysis, the Johansen (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 the formulation is as follows:

$$p_{it} = A_1 p_{it-1} + \varepsilon_t \quad \text{...(5)}$$

So that

$$\Delta p_{it} = A_1 p_{it-1} - p_{it-1} + \varepsilon_t \quad \text{...(6)}$$

$$\Delta p_{it} = (A_1 - I) p_{it-1} + \varepsilon_t \quad \text{...(7)}$$

$$\Delta p_{it} = \Pi p_{it-1} + \varepsilon_t \quad \text{...(8)}$$

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 Π is the (A_1-1) matrix.

The rank of (A_1-1) matrix equals the number of co-integrating vectors. The crucial thing to check is whether (A_1-1) consists of all zeroes or not. If it does, then it implies that all the $\{p_{it}\}$ in the above VAR are unit root processes, and there is one linear combination of which is stationary, and hence the variables are not co-integrated. The rank of matrix Π is equal to the number of independent co-integrating vectors.

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

$$\lambda_{trace}(r) = -T\sum_{j=r+1}^{n} \ln(1-\hat{\lambda}_j) \qquad \ldots(9)$$

where, λ_j denotes the estimated values of the characteristic roots (eigen values) obtained from the estimated Π matrix; and T is the number of usable observations.

After establishing, by the use of Johansen procedure that two markets were co-integrated, we conducted Granger (1969) causality tests to find out the order and direction of short-term and long-term equilibrium relationships. Whether market p_1 Granger causes market p_2 or vice-versa was checked using Equation (10):

$$p_{it} = c + \sum_{j=1}^{n}(\phi\, p_{1t-j} + \delta_j p_{2t-j}) + \varepsilon_t \qquad \ldots(10)$$

A simple test of the joint significance of δ_k was used to check the Granger causality, i.e.

$H_0 : \delta_1 = \delta_2 = \ldots\ \delta_n = 0.$

Error Correction Model (ECM)

After establishing the co-integrating relationships between the two price series, we constructed the Vector Error Correction Model (VECM) to find the short-term disturbances and the adjustment mechanism to estimate the speed of adjustment. The ECM explains the difference in y_t and y_{t-1} (i.e. Δy_t) by Equation (11):

$$\Delta y_t = a + \mu(y_{t-1} - \beta x_{t-1}) + \sum\nolimits_{i=0}^{i=t}\delta_i \Delta x_{t-i} + \sum\nolimits_{i=1}^{i=t}\gamma_i \Delta y_{t-i} \qquad \ldots(11)$$

It includes the lagged differences in both x and y, which have a more immediate impact on the value of Δy_t. For example, if Δx_t increases by one percentage point, then Δy_t would increase by δ percentage point. The value of β indicates the percentage point would change in the long-run in response to changes in x. Therefore, part of the change in Δy_t could be explained by y correcting itself in each period to ultimately reach the long-run path with x. The amount by which the value of y changes (or corrected) in each period is signified by μ. This coefficient (μ) indicates the percentage of the remaining amount that y has to move to return to its long- run path with x.

In explaining changes in a variable, the ECM accounts for its long-run relationship with other variables. The advantage of ECM over an ordinary OLS model is that it accounts for dynamic relationships that may exist between a dependent variable and explanatory variable, which may span several periods.

Results and Discussion

Trends in Arrivals and Prices of Wheat

Table 1 shows that between 1997 and 2011 both market arrivals and prices of wheat increased in all the selected markets, except for the arrivals in Nagpur market. The increase in market arrival was highest in Washim, followed by Shrirampur, Yeola, Akluj, Aurangabad and Akole. On the other hand, increase in price was highest in Aurangabad, followed by Nagpur, Washim, Yeola, Akluj, Akole and Shrirampur. In Maharashtra, 90 per cent of people consume wheat and 10 per cent of people consume rice (Gandhi and Koshy, 2006).

Seasonality in Arrivals and Prices of Wheat

The seasonal variations in price of wheat, presented in Table 2, reveal that indices of seasonal price variation were highest in January in all the selected markets, except in the Akole market where it was highest in February. The months for lowest seasonal price variations were different in these markets. It was April in the Nagpur and Yeola markets, June in the Aurangabad and Shrirampur markets, August in the

Table 1. Trends in prices and arrivals of wheat in major wholesale markets of Maharashtra, 1997-2011

Markets	Coefficient of linear trend	
	Change in price (₹/q/year)	Change in arrival (q/year)
Nagpur	y = 52.05x + 594.05	y = -3838.40x + 145659
Aurangabad	y = 52.09x + 553.39	y = 228.33x + 2974.5
Akluj	y = 43.29x + 630.98	y = 443.74x + 3662
Washim	y = 47.12x + 530.33	y = 6807.30x - 9615.9
Yeola	y = 44.86x + 539.15	y = 901.30x - 2893.7
Shrirampur	y = 41.99x + 624.2	y = 3963.30x - 10384
Akole	y = 43.07x + 586.28	y = 14.83x + 2358.1

Table 2. Seasonal indices of monthly prices of wheat in selected markets of Maharashtra, 1997-2011

Month	Seasonal Index – Price (%)						
	Nagpur	Aurangabad	Akluj	Washim	Yeola	Shrirampur	Akole
January	103.4	106.5	103.3	103.1	104.4	104.4	101.7
February	102.0	102.1	103.2	101.8	101.5	103.0	103.1
March	98.0	96.6	99.1	97.9	98.0	99.2	99.6
April	97.6	98.3	100.7	99.5	97.0	99.0	98.8
May	99.7	99.7	98.7	99.5	97.5	97.9	100.3
June	99.0	96.2	98.5	98.7	97.8	96.7	100.8
July	100.1	98.6	99.4	99.5	100.0	98.7	99.0
August	99.7	99.8	98.3	99.4	101.3	99.9	99.7
September	99.1	99.1	98.7	98.1	99.5	98.7	99.5
October	98.7	97.8	98.6	98.4	100.6	98.8	98.0
November	101.0	101.8	100.5	102.1	101.0	101.3	99.4
December	101.7	103.5	101.0	102.0	101.3	102.5	100.1

Akluj market, September in the Washim market and October in the Akole market. The price of wheat starts increasing from November and reaches peak in January in almost all the selected markets. The lower price indices observed from March to October was due to higher influence of arrivals on prices of wheat in these months.

Table 3 shows the seasonal variation in the arrivals of wheat. In all the selected markets, arrival was more in the months of March and April. In the markets of Nagpur, Aurangabad and Akluj, the highest arrivals were seen in April, whereas in Nagpur, Aurangabad and Akluj markets the arrivals were low during December-February. This seasonal pattern of market arrivals was the result of inadequacy of storage facilities and inability of the farmers to withhold the stocks (Wadke, 2013).

Seasonal Movement of Wheat Arrival and Prices

The intra year price rise (IPR) for wheat over the next several years has important implications for producers, merchandisers, and consumers. For different markets in Maharashtra, the intra-year variations in wheat prices ranged between 5.09 and 10.71 per cent (Table 4), the values of average seasonal price variation (ASPV) ranged between 10.16 and 4.96 per cent, being highest for the Aurangabad market and lowest for Akluj market. The intra-year variations and average seasonal price variation in wheat may have important implications for the decisions related to pricing annual production. The coefficients of variation for prices ranged from 3.00 per cent (Aurangabad market) to 1.37 per cent (Akluj market). The coefficients of variation for arrival ranged from 108.60 per cent (Nagpur market) to 34.25 per cent (Yeola market). The results

Table 3. Seasonal indices of monthly arrivals of wheat in selected markets of Maharashtra, 1997-2011

Month	Seasonal Index – Market arrival (%)						
	Nagpur	Aurangabad	Akluj	Washim	Yeola	Shrirampur	Akole
January	22.2	28.2	45.1	70.3	86.2	110.7	232.5
February	25.7	43.0	36.5	206.8	141.2	123.4	140.2
March	235.9	207.6	207.7	233.9	156.0	212.2	155.8
April	357.9	280.8	275.0	180.5	149.8	191.0	133.5
May	195.7	125.7	122.7	128.5	111.3	103.2	72.2
June	127.4	78.0	79.6	76.0	79.6	80.1	61.4
July	61.3	50.9	58.2	42.0	54.3	47.5	48.3
August	42.8	76.5	59.0	38.1	59.2	39.3	35.1
September	44.7	84.7	76.2	62.7	71.5	53.8	51.4
October	39.6	100.2	92.4	55.1	103.8	71.2	76.2
November	25.6	71.5	79.1	56.5	103.3	78.5	79.9
December	21.1	52.7	68.5	49.6	83.8	89.1	113.5

Table 4. Descending order of wheat markets according to IPR, ASPV and CV

Market	IPR (%)	Market	ASPV (%)	CV (%)			
				Market	Price	Market	Arrival
Aurangabad	10.71	Aurangabad	10.16	Aurangabad	3.00	Nagpur	108.60
Shrirampur	7.96	Shrirampur	7.66	Shrirampur	2.30	Aurangabad	73.91
Yeola	7.63	Yeola	7.35	Yeola	2.15	Akluj	71.15
Nagpur	5.94	Nagpur	5.77	Akluj	1.78	Washim	69.49
Washim	5.31	Washim	5.17	Washim	1.77	Akole	57.26
Akole	5.20	Akole	5.07	Nagpur	1.73	Shrirampur	53.87
Akluj	5.09	Akluj	4.96	Akole	1.37	Yeola	34.25

establish a negative relationship between the arrivals of wheat and its price in the state.

Relationship between Price and Market Arrivals of Wheat

To study the nature of relationship between wheat prices and market arrivals, linear regression equations were estimated and the results are presented in Table 5. The wholesale price has depicted a positive relationship with its immediate lag and a negative relationship with arrival in some of the markets. The equation shows that a rupee increase in lag period price would increase the current price by 0.94 to 1.00 rupee per quintal in the current period. The negative values of coefficient associated with arrivals indicate that an increase in arrivals by one quintal would decrease the price by 0.01 to 0.04 rupee per quintal.

Market Integration

To examine the market integration, Augmented Dickey Fuller (ADF) test for unit root test was conducted and the results are presented in Table 6. The ADF values were higher than the critical values at 1 per cent level, indicating the existence of unit root in the series, implying non-stationary nature of the data. At the first difference level, the ADF values were less than the critical values at 1 per cent level of significance, suggesting that the price series were free from the consequences of unit root. This implied that the price series were stationary at the first difference level.

Johansen's Multiple Co-integration Test

To determine the long-run relationship between the price series from a range of seven price series,

Table 5. Relationship between price and arrival of wheat in major wholesale markets of Maharashtra

Market	Price and arrival equation						
Nagpur	$P_t =$	23.89	+	$0.98P_{t-1}$	–	$0.02Y_t$	
		(1.48)		(64.47)***		(-0.913)	$R^2 = 0.96$
Aurangabad	$P_t =$	60.17	+	$0.940P_{t-1}$	+	$0.01Y_t$	
		(2.34)**		(36.56)***		(0.32)	$R^2 = 0.88$
Akluj	$P_t =$	41.65	+	$0.96P_{t-1}$	+	$0.01Y_t$	
		(1.90)*		(43.58)***		(0.64)	$R^2 = 0.92$
Washim	$P_t =$	16.43	+	$0.99P_{t-1}$	–	$0.04Y_t$	
		(1.00)		(52.12)***		(-1.87)*	$R^2 = 0.95$
Yeola	$P_t =$	4.81	+	$1.00P_{t-1}$	–	$0.04Y_t$	
		(0.34)		(60.44)***		(-2.41)**	$R^2 = 0.96$
Shrirampur	$P_t =$	16.18	+	$0.99P_{t-1}$	–	$0.01Y_t$	
		(1.06)		(59.75)***		(-0.78)	$R^2 = 0.96$
Akole	$P_t =$	21.44	+	$0.97P_{t-1}$	+	$0.02Y_t$	
		(1.22)		(54.81)***		(0.82)	$R^2 = 0.95$

Note: Figures within the parentheses are t-values.
***, ** and * denote significance at less than 1 per cent, 5 per cent and 10 per cent levels, respectively.

Table 6. ADF test results of wheat prices in different markets of Maharashtra

Market	Level series	First difference	Critical value
Nagpur	-1.084	-16.124	
Aurangabad	-1.737	-12.873	
Akluj	-1.123	-13.009	
Washim	-1.256	-16.208	-3.467*
Yeola	-1.145	-13.502	
Shrirampur	-1.201	-12.814	
Akole	-0.717	-13.844	

Note: *Significant at 1 per cent level

Johansen's multiple co-integration test was employed and the results presented in Table 7, reveal that out of seven markets, four were cointegrated at 1 per cent level of significance, implying that the selected wheat markets had long-run equilibrium relationship and there existed co-integration among these markets.

The integration of wheat prices between selected pairs of markets was tested using Johansen's Co-integration test. It showed that the Nagpur market was cointegrated with Aurangabad and Akole markets although these markets are far apart geographically. The Akluj market was cointegrated with Washim, Yeola, Shrirampur and Akole markets. The Washim market was cointegrated with Akluj, Yeola and Akole markets. The Yeola market was cointegrated with Akluj, Washim, Shrirampur and Akole markets. The Shrirampur market was cointegrated with Akluj, Yeola and Akole markets. The Akole market was cointegrated with all the selected markets. Therefore, it could be inferred that wheat markets are integrated within the state.

Granger Causality Tests

The results of pair-wise Granger causality test (Table 8) showed that there was bidirectional influence of prices of Aurangabad and Akole markets on all other selected markets, except no causality between Akole and Yeola markets. The price in the Nagpur market has depicted a bidirectional influence on the price in Aurangabad, Yeola and Akole markets. The Akluj market price has shown a bidirectional influence on the price of Aurangabad and Yeola markets. The Washim market price has revealed a bidirectional influence on the prices of Aurangabad, Yeola, Shrirampur and Akole markets. The Yeola market price had a bidirectional influence on the prices of Nagpur, Aurangabad and Washim markets. The Shrirampur market price has shown a bidirectional influence on the prices of Aurangabad, Washim and Akole markets.

Table 7. Results of multiple co-integration analysis

Hypothesized No. of CE(s)	Eigen value	Trace statistic	Critical value+ (Significance level: 1 %)	Critical Value++ (Significance level: 5 %)
None **	0.282970	203.6968	133.57	124.24
At most 1 **	0.251379	145.4852	103.18	94.15
At most 2 **	0.199805	94.81874	76.07	68.52
At most 3 **	0.151671	55.81123	54.46	47.21
At most 4	0.089902	27.02608	35.65	29.68
At most 5	0.054746	10.54065	20.04	15.41
At most 6	0.003923	0.687961	6.65	3.76

Note: Trace test indicates 4 cointegrating equation(s) at both 5 per cent and 1 per cent levels, respectively
* and (**) denote rejection of the hypothesis at 5 per cent and 1 per cent levels, respectively

Table 8. Results of pairwise Granger causality tests in different wheat markets of Maharashtra

Market	Nagpur	Aurangabad	Akluj	Washim	Yeola	Shrirampur	Akole
Nagpur	1	↔	→	→	↔	→	↔
Aurangabad	↔	1	↔	↔	↔	↔	↔
Akluj	x	↔	1	x	x	x	↔
Washim	x	↔	→	1	↔	↔	↔
Yeola	↔	↔	→	↔	1	→	→
Shrirampur	x	↔	→	↔	x	1	↔
Akole	↔	↔	↔	↔	x	↔	1

Note: ↔ : Bidirectional, → : Unidirectional, and x : No causality

The Akluj market price has depicted a unidirectional causality on the prices of Nagpur, Washim, Yeola and Shrirampur. This leads to the conclusion that wheat prices adjust in markets according to demand and supply situation in the state.

Vector Error Correction Model

The estimates of vector error correction model, presented in Appendix 1 reveal that the coefficient of speed of adjustment for different pairs of markets was negative in almost all the markets, implying that prices in different markets tend to converge in the long-run. The coefficient of speed of adjustment ranged from -0.004 to -0.025, which indicates that between 0.4 per cent and 2.5 per cent of divergence from the long-run equilibrium was being corrected each month. The process of adjustment, however, was relatively faster between the markets of Shrirampur - Aurangabad, Yeola – Akluj, Akole – Aurangabad and Akluj – Shrirampur. This might be due to lesser transfer and transaction costs in these markets due to proximity and better infrastructure.

The effects of lagged prices in the selected markets were positive as well as negative, suggesting that, in the short-run, price shocks were contemporaneously transmitted in these markets but not fully. In the Nagpur market, its own lagged prices and the prices in Aurangabad market tended to move closer. In Aurangabad market, only its own lagged prices tended to move closer. The short-run dynamics, thus, indicates that the changes in prices in the Akluj market were transmitted to almost all other selected markets. The price in Washim market was transmitted to Nagpur, Akluj, Washim, Yeola and Akole markets. The price in Yeola market was transmitted to Aurangabad, Akluj, Washim and Akole markets. The price in Shrirampur market was transmitted to Nagpur, Aurangabad Yeola markets. The price at Akole market was transmitted to

Nagpur, Aurangabad, Akluj, Washim and Yeola markets. To strength the linkage and inter-connectedness among markets for faster transmission of price and management of a commodity from surplus area to deficit area, the clarion call is to enhance the development of market infrastructure, use of information and technology in transaction of goods, processing, transportation and other back-end supply chain of wheat. This would definitely help in the development of single integrated economic market in the state.

Conclusions

The market performance of wheat in Maharashtra state has been studied on the basis of monthly arrivals and wholesale prices data for 15 years (1997 to 2011). The study has revealed an increasing positive trend in arrivals and prices of wheat in all the selected markets. An inverse relationship has been found between market arrivals and prices of wheat. The market prices in general, attains a long-run equilibrium relationship/converge in the long-run after restating and correcting prices ranging from -0.04 per cent to -0.25 per cent per month in the state. There is integration even among the geographically dispersed wheat markets. However, some market pairs have shown bidirectional causality and others have depicted unidirectional causality. In the short- run, wheat markets have been found well-integrated and the price changes are transmitted contemporaneously, though not fully. This shows that wheat markets in the region have acquired competitive strength in price formation after correcting short-run and long-run fluctuations. The speed of adjustment, however, varies across different market pairs. The strengthening of physical infrastructure, use of information and communication technology and well-defined transparent agricultural policy/market measures in the state will help in the development of single uniform economic market in the region in particular and country in general.

Acknowledgement

The authors thank the referee for helpful suggestions on the earlier draft of the paper.

References

Acharya, S.S., Chand, R., Birthal, P. S., Kumar, Shiv and Negi, D.S. (2012) *Market Integration and Price Transmission in India: A Case of Rice and Wheat with Special Reference to the World Food Crisis of 2007-08*. Food and Agriculture Organization, Rome. pp. 1-67.

AGMARKNET (Agricultural Marketing Information Network). Available at: http://www.agmarknet.nic.in.

Engle, R. and Granger, C. (1987) Co-integration and error correction–Representation and testing. *Econometrica*, **55**: 251-276.

Gandhi, V. P. and Koshy, A. (2006) *Wheat Marketing and its Efficiency in India*. Working Paper No. 2006-09-03. Indian Institute of Management (IIM), Ahmedabad.

Granger, C.W.J. (1969) Investigating causal relations by econometric models and cross-spectral methods. *Econometrica*, **37**: 424-438.

Johansen, S. (1988) Statistical analysis of co-integration vectors. *Journal of Economic Dynamics and Control*, **12**(2-3): 231-254.

Rapsomanikis, G., Hallam, D., Comforti, P. and Sharma, R. (2006) *Market Integration and Price Transmission in Selected Food and Cash Crop Markets of Developing Countries: Review and Applications*. Commodities and Trade Division, Food and Agriculture Organization, Rome. pp. 1-20.

Wadke, Rahul (2013) Maharashtra plans steel silos to store grains. *The Hindu, Business Line,* 6 December.

Revised received: August, 2014; Accepted: November, 2014

Appendix 1

Results of vector error correction model with two lag periods in different wheat markets of Maharashtra

Error correction	D (ln_NAGPUR)	D (ln_AURANGABAD)	D (ln_AKLUJ)	D (ln_WASHIM)	D (ln_YEOLA)	D (ln_SHRIRAMPUR)	D (ln_AKOLE)
CointEq1	-0.006682	-0.015326	-0.004459	-0.007358	0.004615	-0.025449	-0.010742
	[-0.86604]	[-0.99091]	[-0.54984]	[-0.91977]	[0.69024]	[-4.07287]	[-1.61655]
D(ln_NAGPUR(-1))	-0.135541	-0.055369	0.130601	0.183101	0.137375	0.149000	0.162461
	[-1.65447]	[-0.33714]	[1.51666]	[2.15542]	[1.93510]	[2.24570]	[2.30254]
D(ln_NAGPUR(-2))	-0.095583	0.003948	0.081278	0.098314	0.049342	0.076784	0.007103
	[-1.22284]	[0.02519]	[0.98927]	[1.21299]	[0.72847]	[1.21294]	[0.10552]
D(ln_AURANGABAD(-1))	0.019492	-0.436982	0.019771	0.014660	0.027473	0.059203	0.021704
	[0.49526]	[-5.53839]	[0.47791]	[0.35922]	[0.80553]	[1.85734]	[0.64028]
D(ln_AURANGABAD(-2))	0.006642	-0.212516	0.050741	0.014027	0.024175	0.043516	0.028611
	[0.17632]	[-2.81411]	[1.28147]	[0.35909]	[0.74057]	[1.42635]	[0.88188]
D(ln_AKLUJ(-1))	0.066554	0.074134	-0.376119	0.140891	0.092485	-0.057012	0.062399
	[0.75503]	[0.41953]	[-4.05948]	[1.54145]	[1.21081]	[-0.79860]	[0.82194]
D(ln_AKLUJ(-2))	-0.022291	-0.188208	-0.283879	-0.132212	-0.127487	-0.193627	-0.058589
	[-0.23903]	[-1.00675]	[-2.89613]	[-1.36727]	[-1.57763]	[-2.56375]	[-0.72948]
D(ln_WASHIM(-1))	-0.028844	0.267174	-0.050945	-0.422116	-0.101006	0.005281	-0.043085
	[-0.26178]	[1.20954]	[-0.43987]	[-3.69452]	[-1.05787]	[0.05918]	[-0.45402]
D(ln_WASHIM(-2))	0.136872	0.426018	0.106737	-0.180921	0.207473	0.169179	0.014802
	[1.35784]	[2.10821]	[1.00740]	[-1.73092]	[2.37523]	[2.07233]	[0.17050]
D(ln_YEOLA(-1))	0.126198	0.080814	0.148400	0.258728	-0.031583	0.006779	-0.154947
	[0.77496]	[0.24755]	[0.86699]	[1.53223]	[-0.22382]	[0.05140]	[-1.10479]
D(ln_YEOLA(-2))	0.029894	-0.086940	-0.305946	-0.271335	-0.053450	0.023764	-0.222587
	[0.20311]	[-0.29467]	[-1.97767]	[-1.77794]	[-0.41910]	[0.19936]	[-1.75600]
D(ln_SHRIRAMPUR(-1))	-0.028394	0.188212	0.340526	0.111688	0.147553	-0.108513	0.428200
	[-0.19450]	[0.64313]	[2.21926]	[0.73784]	[1.16644]	[-0.91783]	[3.40580]
D(ln_SHRIRAMPUR(-2))	-0.248670	-0.471646	0.171483	0.361420	-0.205031	-0.335144	0.107419
	[-1.68092]	[-1.59035]	[1.10281]	[2.35608]	[-1.59939]	[-2.79726]	[0.84309]
D(ln_AKOLE(-1))	-0.002039	-0.231050	-0.077135	-0.215681	-0.039076	0.103452	-0.222187
	[-0.01949]	[-1.10163]	[-0.70142]	[-1.98812]	[-0.43101]	[1.22094]	[-2.46584]
D(ln_AKOLE(-2))	0.022801	0.088803	0.104117	-0.020044	-0.041530	0.093801	-0.205395
	[0.22860]	[0.44412]	[0.99312]	[-0.19380]	[-0.48051]	[1.16121]	[-2.39103]
C	0.003918	0.004917	0.002189	0.002787	0.002713	0.002161	0.003347
	[1.08099]	[0.67667]	[0.57446]	[0.74161]	[0.86367]	[0.73627]	[1.07220]

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