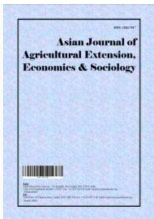

Asian Journal of Agricultural Extension, Economics & Sociology

39(3): 15-20, 2021; Article no.AJAEES.66138
ISSN: 2320-7027

Price Dynamics of Domestic and International Wheat Markets: A Vector Error Correction Mechanism (VECM) Approach

A. G. Sabhaya[1*], S. M. Upadhyay[1], P. R. Vekariya[1] and B. Swaminathan[2]

[1]Department of Agricultural Statistics, Junagadh Agricultural University, Junagadh – 362001 (Gujarat), India.
[2]Department of Agricultural Economics, Junagadh Agricultural University, Junagadh – 362001 (Gujarat), India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAEES/2021/v39i330541
Editor(s):
(1) Dr. Zhao Chen, University of Maryland, USA.
Reviewers:
(1) Asif Khan, Zhejiang University, China and Hazara University, Mansehra, Pakistan.
(2) Sarkhosh Seddighi Chaharborj, Carleton University, Canada.
(3) Javier Emmanuel Anguiano Pita, University of Guadalajara, Mexico.
Complete Peer review History: http://www.sdiarticle4.com/review-history/66138

Original Research Article

Received 15 January 2021
Accepted 22 March 2021
Published 16 April 2021

ABSTRACT

Market integration in agricultural commodities is vital for both developed and developing countries alike. If prices are not dreamily transmitted, then it may lead to biases in production and distribution. The strength of interdependence among markets and the speed in which the changes are passed through determine the degree of integration and the global efficiency of markets. This study examines the long-run and short-run integration of domestic and international wheat markets using Co-integration approach within the framework of Vector Error Correction Mechanism (VECM). A sample of two domestic wheat markets comprising two from the national wheat markets of Mathura (UP) and Khanna (Punjab) were selected along with two international wheat markets comprising from United States and Argentina. Analysis was carried out using the monthly price

**Corresponding author: E-mail: ankitsabhaya031@gmail.com;*

data between January 2003 and Dec 2019. Findings discovered that the prices became stationary merely upon first differencing. The presence of integration was confirmed among markets involving that there is price conduction.

Keywords: Stationarity; market integration; co-integration; short-run disequilibrium.

1. INTRODUCTION

The extent of agricultural market integration is relevant to policy makers. A weak degree of integration signposts that, in the face of the institutional efforts to achieve a unified market, prices are peaceably transmitted, and therefore, misallocation of possessions and bends of production and distribution might arise. The greater the degree of integration, the more efficient would be the interacting markets. Evaluation of market integration has usually been undertaken by analyzing price interactions [1]. As markets become more integrated, it is expected that every market employs information from the others when forming its own price expectations. Geographically separated markets are integrated if goods and information flow freely among them and, as a result, prices are linked. When inter-market margins are larger than transfer costs then profitability opportunities are not being exploited and markets are not efficiently connected. In integrated markets, price changes in one region are transmitted to the other regions. The extent and the speed to which changes are passed through, and the strength of the interdependence among markets are indicators of the degree of integration and global efficiency of markets performance.

Although differences in the size of Indian and international wheat auction markets exist, it is not possible to delimit deficit versus surplus or producing versus consuming countries, as long as intra-industry trade prevails. On the other hand, the multilateral patterns of trade are likely to draw complex interactions and simultaneous determination of market prices can be better described in a multivariate framework. As a consequence, a Vector Error Correction Mechanism (VECM) is appropriate to study spatial and temporal price linkages between the Indian and international wheat markets. The VECM allows considering the long-run implications of co-integration along with short-run corrections. Hence an effort has been made to estimate spatial and temporal addition and to study the dynamic elements of both long and short run price communication in the local and international wheat markets.

2. MATERIALS AND METHODS

Both domestic and international wheat markets were considered for the study. In the case of local markets, two markets *viz*. Junagadh and Rajkot, domestic markets, two markets *viz*. Punjab (Khanna) and UP (Mathura) from the traditional wheat growing states of Punjab and UP were selected for the present study on the basis of volume of transactions, experts' opinion and availability of data. The wheat markets of United State and Argentina are the largest world wheat producers and they together hold more than 40 per cent of world wheat trade in of year. Thereby, any changes to wheat prices in these market can have worldwide ramification and it effect can be felt not only in India’s export of wheat but domestic consumption price as well. The domestic market prices of wheat was collected from the portals of Agmarknet. The price series for the international markets were obtained from the portal of UNCTAD. Time-series data of monthly duration covering the period between January 2004 and December 2019 was obtained. The price series were deflated to form real price trends. In the case of domestic wheat market prices, the series were deflated by wholesale price index for cereals. The US$ deflator is used to deflate the international wheat market prices. Then the prices was converted into domestic currency using official foreign exchange rates. The analysis were carried out using the Eviews 11.04 and STATA 16.0 statistical software packages.

2.1 Establishing Stationarity

Before analyzing any time series data testing for stationarity[5] is necessary [2] since the data has the presence of trend components. If the series was found to be non-stationary, then the first differences of the series were to be tested for stationarity. The number of times (d) a series was differenced to make it stationary is referred as the order of integration, I (d). The Augmented Dickey Fuller (ADF) test was applied by running the regression of the following formula:

$$\Delta Y_{it} = \alpha + \beta_i T + \delta_i Y_{it-1} + b_i \sum_{i-1}^{p} \Delta Y_{it-1} + e_t \qquad (1)$$

Where; Y_{it} = Price of a commodity in a given market 'i' at a time't'; $\Delta Y_{t-i} = Yt_{-1} - Y_{t-2}$ (t-i – lagged prices and Δ – differenced series); T = Time trend; α = Drift parameter; β_i, δ_i and b_i = Coefficients; and e_t = Pure white noise error-term. p is the optimal lag value which is selected on the basis of Schwartz information criterion (SIC).

2.2 Johansen's Cointegration

It is possible that individual time series of the commodity prices may be non-stationary in levels, but a linear combination of them may be stationary indicating a long run equilibrium relationship between them [3]. If a linear combination of two non-stationary series is stationary, then the two series are considered to be co-integrated. Co-integrated prices do not gist apart in the long-run and tend to move just before a shared equilibrium path [4]. To test whether or not the remaining run of regression between the two time series is stationary, co-integration tests start with the premise that for a long-run equilibrium relationship to exist between two variables it is necessary that they should have the same inter temporal characteristics. The ADF test was supplemented by Johansen-Juselius Maximum Likelihood Method. This test addresses the issues of endogeneity and simultaneity problems in the data series. By this technique, the hypothesis of presence of co-integration vector was formulated on a group of non-stationary series, as the hypothesis of reduced rank of the long-run impact matrix. Likelihood ratio and maximum likelihood tests were applied to derive test statistics for the hypothesis of given number of co-integration vectors and their weights. Inference concerning linear restrictions on the co-integration vectors and their weights were performed using usual chi square methods [5]. Only variables of the equal order of integration make the grade for the pair wise co-integrating relations. The exact linear combinations experienced are the residuals from a fixed co-integrating regression such as:

The Johansen technique examines a vector auto regressive (VAR) model of Y_t, an (n x I) vector of variables that are integrated of the order one - I time series. This VAR can be expressed as Equation (2):

$$Y_t = \mu + \sum_{i=1}^{p-1} \Gamma_i Y_{t-1} + \Pi Y_{t-1} + \varepsilon_t \quad (2)$$

where, Γ and Π are matrices of parameters, p is the number of lags (selected on the basis of Schwarz information criterion), ε_t is an (n x I) vector of innovations. The presence of at least one cointegrating relationship is necessary for the analysis of long-run relationship of the prices to be plausible. To detect the number of co-integrating vectors, Johansen suggested two tests to identify the number of co-integrating.

1. An analysis is used as an aid in choosing between the competing models. It is defined as $-2L_m + m \ln n$ where n is m the sample size, L_m is the maximum log-likelihood of the model and m is the number of parameters in the model.
2. Non-stationary means that the mean and variance of the time series are unstable throughout the period and the auto-co-variance is varying by the time change.

Vectors in the system, viz., the trace test and the maximum eigen value test, shown in Equations (3) and (4), respectively.

$$J_{trace} = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \quad (3)$$

$$J_{max} = -T \ln(1 - \hat{\lambda}_i + 1) \quad (4)$$

Where, T is the sample size and $\hat{\lambda}_i$ is the i^{th} largest canonical correlation. The trace statistics provides whether 'r' co-integrating vectors are present in the system against the alternative hypothesis that system is already stationary (*i.e.*, r cointegrating vectors are present in the system). While, the maximum eigen value statistics provides whether the rank r is against the alternative hypothesis that rank is (r + 1).

2.3 Error Correction Model

Even after confirming the existence of a long-term equilibrium in the market pairs, there is a possibility of short-run disequibrium, due to which, the price change in one market may not get transmitted immediately to the other market and takes some time for such transmission. For example, discontinuities in trade correspond to slow speed of short-run adjustment to the long-run equilibrium were estimated by using the Error

Correction Model (ECM) which is given below in the following specification:

$$\Delta Y_{t-i} = \alpha_0 + \alpha_1 \Delta X_{t-i} + \alpha_2 e_{t-1} + \varepsilon_t \quad (5)$$

Where; $\Delta Y_{t-i} = Y_{t-1} - Y_{t-2}$; α_0 Constant term; $\alpha_1, \alpha_2 =$ Speed of price transmission; $e_{t-1} =$ Lagged error term of the co-integration model; and $\varepsilon_t =$ White noise error-term.

3. RESULTS AND DATA ANALYSIS

The co-integration among the price series in turn requires checking of order of integration in the given price series and it cannot be integrated in the presence of unit root, the same can be examined through conducting a stationarity test. Therefore, Augmented Dickey-Fuller (ADF) test was employed to check whether the time series data on wheat prices in the selected markets were stationary at their level followed by their differences. The null hypothesis of non-stationarity was tested based on the critical values reported by MacKinnon [6]. The estimated test statistics from the ADF test for the wheat market prices in levels and first-difference are reported in Table 1. Therefore, the prices were found to be non-stationary in their levels for all the market but stationary in first differences. This implied that the price series of all the markets were stationary at their first differences. Hence, the value of ***d*** was taken as 1 *i.e*. I (1) for all the markets.

Having confirmed that the price series were stationary in their first differences, co-integration between the markets was tested using Johansen-Juselius maximum likelihood procedure for the presence of long run equilibrium among the selected wheat markets. The results of co-integration test showed at least two co-integration equations at 5 per cent level of significance indicated that the selected wheat markets having long run equilibrium relationship (Tables 2, 3).

As it could be seen from the Table 4, the estimated error- term co-efficients revealed that in the domestic Mathura wheat market 9 per cent and international Argentina wheat market 25 per cent disequilibrium got corrected within a month by changes in its own prices and the remaining was influenced by other internal and external market forces. The co-efficients of own lagged price of Khanna wheat market was also found significant and revealed that the impact of its own price gets corrected within one and two month lag indicating the short-run price movements along the long-run equilibrium path was stable also found significant one month lag in USA Wheat market.

The co-efficients was observed that more than 46 per cent, 21 per cent and 23 per cent of short-run disequilibria got corrected with one-month lag in the Junagadh market with relation to Rajkot, Mathura and Khanna markets, respectively. The short run disequilibrium was found to exist at one-month lag period with the speed of convergence at 33 per cent and 27 per cent with relation to Mathura, Junagadh and Khanna markets, respectively. With relation to Rajkot market about 23 per cent of short-run disequilibrium in Junagadh market got corrected with one-month lag period. Further, the error correction estimates for USA market revealed that it was not at all affected by national wheat market prices in the long-run equilibrium path and short-run equilibrium affected. At the same time the short-run disequilibria of the Argentinean market with relation to the markets of USA was found significant at one and two-month lag period and the speed of convergence was at 39 per cent and 23 per cent, respectively.

Table 1. Results of unit root test for wheat prices at different markets

Wheat Market	Augmented Dickey - Fuller (ADF)	
	Level	1st Differnce
Rajkot	-0.619364 (0.8623)	-12.32852* (0.0000)
Junagadh	-0.892441 (0.7892)	-11.67637* (0.0000)
Mathura	-0.419793 (0.9021)	-12.32959* (0.0000)
Khanna	-0.032105 (0.9537)	-12.85559* (0.0000)
Argentina	-2.61633 (0.0913)	-13.2646* (0.0000)
USA	-2.413628 (0.1392)	-11.64523* (0.0000)

*Null Hypothesis: Series has a unit root, Statistical critical value of 1 per cent = -3.4625, 5 per cent = -2.8756, * indicates of significance of values at 1 per cent*

Table 2. Unrestricted co-integration rank test (trace) between wheat markets

Hypothesized		Trace	0.05	
No. of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**p-value**
None *	0.240715	136.6810	95.75366	0.0000
At most 1 *	0.172770	81.33009	69.81889	0.0046
At most 2	0.107583	43.20580	47.85613	0.1276
At most 3	0.075463	20.32766	29.79707	0.4009
At most 4	0.022307	4.556683	15.49471	0.8539
At most 5	0.000110	0.022192	3.841466	0.8815

*Note: Trace test indicates 2 cointegrating, * denotes rejection hypothesis at the 5 per cent level*

Table 3. Unrestricted cointegration rank test (maximum eigenvalue) between wheat markets

Hypothesized		Max-Eigen	0.05	
No. of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob**
None *	0.240715	55.35087	40.07757	0.0005
At most 1 *	0.172770	38.12429	33.87687	0.0146
At most 2	0.107583	22.87814	27.58434	0.1787
At most 3	0.075463	15.77098	21.13162	0.2385
At most 4	0.022307	4.534491	14.26460	0.7991
At most 5	0.000110	0.022192	3.841466	0.8815

*Note: Max-eigenvalue test indicates 2 cointegrating eq.(s) at the 5 per cent level, * denotes rejection of the hypothesis at the 5 per cent level*

Table 4. Short-run disequilibrium of price movements in the selected market

Error Correction	D(RJ)	D(JND)	D(MAT)	D(KH)	D(ARG)	D(USA)
CointEq1	0.0220	-0.0283	0.0891**	0.0698*	0.2492**	-0.0816
	(0.0366)	(0.0386)	(0.0272)	(0.0401)	(0.0610)	(0.0495)
D(RJ(-1))	-0.1632	0.2309*	0.0958	-0.0480	0.0077	0.0129
	(0.1074)	(0.1133)	(0.0798)	(0.1175)	(0.1787)	(0.1451)
D(RJ(-2))	-0.2406*	0.0407	0.0360	0.0466	-0.1590	0.1312
	(0.1048)	(0.1106)	(0.0779)	(0.1147)	(0.1744)	(0.1415)
D(JND(-1))	0.4641**	0.1160	0.2131**	0.2316*	-0.1389	0.0929
	(0.0953)	(0.1005)	(0.0708)	(0.1043)	(0.1586)	(0.1287)
D(JND(-2))	0.1296	0.0147	0.1073	0.0179	-0.2871	-0.1724
	(0.0995)	(0.1050)	(0.0740)	(0.1089)	(0.1656)	(0.1344)
D(MAT(-1))	-0.1712	-0.3304**	-0.0958	0.2715*	0.1649	0.0349
	(0.1116)	(0.1177)	(0.0829)	(0.1221)	(0.1856)	(0.1507)
D(MAT(-2))	0.1141	-0.0682	-0.1122	0.1118	-0.0420	0.0444
	(0.1003)	(0.1058)	(0.0745)	(0.1097)	(0.1668)	(0.1354)
D(KH(-1))	-0.0569	0.0407	0.0241	-0.5145**	0.0301	-0.0043
	(0.0785)	(0.0829)	(0.0583)	(0.0859)	(0.1307)	(0.1060)
D(KH(-2))	0.0398	0.0974	0.0148	-0.3100**	0.1709	0.0872
	(0.0789)	(0.0833)	(0.0586)	(0.0864)	(0.1313)	(0.1066)
D(ARG(-1))	0.0076	-0.0117	0.0481	0.0085	0.0434	-0.0525
	(0.0526)	(0.0555)	(0.0391)	(0.0575)	(0.0875)	(0.0710)
D(ARG(-2))	0.0012	0.0649	0.0510	0.0280	0.0288	-0.1636**
	(0.0487)	(0.0514)	(0.0362)	(0.0533)	(0.0810)	(0.0657)
D(USA(-1))	0.0592	0.0962	-0.0006	-0.0080	0.3935**	0.2585**
	(0.0648)	(0.0683)	(0.0481)	(0.0709)	(0.1078)	(0.0874)
D(USA(-2))	-0.0419	-0.0798	-0.0566	-0.0525	-0.2382*	0.0141
	(0.0651)	(0.0687)	(0.0484)	(0.0712)	(0.1084)	(0.0877)

*Note; RJ- Rajkot, JND-Junagadh, MAT-Mathura, KH-Khanna, ARG-Argentina, Slandered error in parentheses, C – Constant, **/ * indicates of significance of 1% and 5% level respectively*

Supporting results have also been obtained by Jordan and Vansickle [1], Mackinnon [6] and Gopal et al. [7].

4. CONCLUSION

The findings provided empirical evidence about the efficiency of domestic and international wheat markets. It was found that the prices of domestic and international maize markets were stationary only at their first differences. With the advent of globalization as the trade barriers and import tariffs were considerably removed, this has resulted in price changes in one market getting passed on to another distant market. Integration of markets is a good indicator of efficiency in the marketing system. In this study a higher degree of market integration in terms of price transmission has been observed. Co-integration tests were also applied to study such long-run relationships of price movements and the domestic markets were found to be integrated with other markets with maximum two co-integrating equations. Moreover, VECM approach confirmed the existence of short-run disequilibria with the speed of convergence ranging between 9 per cent and 51 per cent for short-run price movements to become stable along the long-run equilibrium path.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/66138