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TESTING THE LAW OF ONE PRICE: COTTON MARKET INTEGRATION IN PAKISTAN'S PUNJAB

Khalid Mushtaq*, Faisal Abbas** and Abedullah***
*Department of Agricultural Economics, University of Agriculture, Faisalabad, Palostam
**Centre for Development Research (ZEF), University of Bonn, Germany
***Dept. of Environmental & Resource Economics, University of Agriculture, Faisalabad, Pakistan
Corresponding author's E-mail: khalidmushtaq69@yahoo.Com

Regional market integration in many agricultural commodities has been extensively studied for the insight it provides into the functioning of such markets; such studies provide valuable information about the dynamics of market adjustments, and whether there exist market imperfections, which may justify government intervention. This study empirically estimated the degree of integration in cotton markets of Pakistan's Punjab using the law of one price (LOP) framework and cointegration analysis. Cointegration Results show that all seed cotton markets are highly integrated in the long run. Regression results show that government intervention in terms of seed cotton procurement negatively influenced the degree of market integration. The high degree of market integration observed in this case is consistent with view that Punjab's seed cotton markets are quite competitive and provide little justification for extensive and costly government intervention designed to improve competitiveness to enhance market efficiency.
Keywords: Market integration, cointegration, cotton prices, Punjab.

INTRODUCTION

In a decentralized economic system resource allocation takes place through price signals transmitted by the markets. In developing economies, there are several impediments to the efficient functioning of markets, particularly agricultural commodity markets. These includes not good enough transportation infrastructure, difficulties in access to market information, government-imposed restriction on movement of goods between regions, government monopoly over the marketing and distribution system, and poor enforcement of anti-trust regulation that result in price fixing and Oligopolistic market structures.

Overall market performance may be evaluated in the term of price relationships. Co integration test can be used to examine the stability of price relationship. Although the larger markets that are better connected with the transport and communication network are expected to be well integrated; the same cannot be said about the smaller, more remote markets. Market integration refers to co-movements of prices and more generally, to the smooth transmission of price signals and information across spatially separated markets. Market integration provides important information on how markets work. Such information helps the government to decide the extent to which it should promote market development. If, for example locations A, B, and C are well integrated, then the government may think of withdrawing from, or at least reduce, its efforts to influence the price setting process in those locations. Degree of market integration has often been used as a gauge of the success of market liberalization and structural adjustment policies in developing countries. Market integration leads to market liberalization or price stabilization because of detailed transmission of incentives across the marketing chain. Government of Pakistan tries to stabilize the prices of cotton through price supports or producer subsidy. If markets are well integrated the government will stabilize the prices in one key market and rely on arbitrage to produce the similar outcome in other markets. This reduces the cost of stabilization considerably.

Market integration is subjectively viewed as long run phenomenon. It is present whenever a stable price relationship is established. This means that spatial prices can temporarily deviate from each other in the short run and still be consistent with the idea of an integrated market. The concept of spatial arbitrage is to visualize traders buying in low priced market, transferring the item to a high priced market, and reselling the purchased good in different localities tend towards equality and move together with each other in integrated markets. Markets that are not integrated may convey inaccurate price information that might distort production decisions and contribute to inefficiencies in product markets.

Cotton has greater significance in Pakistan's economy. It accounts for 8.2 percent to value added in agriculture and about 2 percent to GDP. It provides raw materials to local textile industry; the surplus lint cotton is exported. The share of cotton in value added by major crops is about 13 percent. Cotton farming is the

principal source of raw material for the textile industry, employing about 40 percent of the industrial labor. Cotton and cotton products contribute about 10 percent to agriculture GDP and 60 percent to the foreign exchange earnings of the country. Cotton production in Pakistan is concentrated in two provinces, Punjab and Sindh, which jointly account for more than 99 percent of total production (GOP, 2003-04). The main interest of studying price integration among local markets is to be able to identify sets of markets that lead other markets in the price transmission process. Little has been done in the way of empirically evaluating actual cotton market performance in Pakistan. Tahir and Riaz (1997) studied the integration of agricultural commodity markets in southeastern Punjab, Pakistan, using weekly prices of wheat, cotton and rice from 1993 to 1995. The results suggested that there were no market integration for all cotton markets in the short-run because of the periodicity of data used in the study and the integration involved two different stages in the processing chain (cotton lint and seed cotton). The cotton markets were also not integrated in the long-run except Bahalwalnagar. Moreover, smaller markets were more likely to be isolated as compared to large markets.

Besides locating factors at macro level affecting the integration of the markets this study aims critically estimating the extent of market integration in seed cotton markets of Punjab, Pakistan using the law of one price (LOP) framework. The structure of the paper is as follows: Section 2 discusses the LOP, Section 3 discusses the empirical approach, Section 4 discusses the data and results, while Section 5 concludes.

The Law of One Price and Market Integration

Richardson (1978) notes that the LOP is a test of market integration in period t and involves the regression:

$$\Delta P_{1t} = \beta_i + \beta_2 \Delta P_{2t} + u_t \quad t = 1,\ldots,n \qquad (1)$$

where β_1 and β_2 are parameters, Δ represents first differences where for example $\Delta P_{1t}=P_{1t}-P_{1t-1}$, and u_t is an error term with the usual properties. If the joint hypothesis that $\beta_1=0$ and $\beta_2=1$ is not rejected, the two prices are statistically identical and the LOP holds. Equation (1) can be estimated using the original price series or the series in logarithms. The former implies an absolute price difference as the maintained hypothesis while the latter implies a proportional price difference. Ravallion (1986) extends (1) by assuming that price adjustment between markets takes time, and using an error correction model, a nested test for short-run market integration is shown to be equivalent to a test of the LOP. The Granger-causality approach (Alexander and Wyeth, 1994) extends the Ravallion model and uses a single-equation error correction model to test causality between prices. The cointegration approach (Palaskas and Harriss-White, 1993, and Alexander and Wyeth, 1994) is based on the first step of the Engle and Granger (1987) two-step method. Estimating:

$$P_{1t} = \beta_1 + \beta_2 P_{2t} + u_t \quad t = 1,\ldots,n \qquad (2)$$

a test of long-run spatial market integration is equivalent to testing the stationarity of the residuals, u_t.

MATERIALS AND METHODS

The approach adopted here is based on the LOP in (2) but follows the Sims' (1980) vector autoregressive (VAR) methodology, unlike single-equation methods, the exogeneity of one price is not imposed *ex ante*; long-run market integration is examined using Johanson's (1988) cointegration procedure. This approach incorporates important features of previous models. First, both prices are determined by their current and past values. Second, the null hypothesis of no cointegration between two prices is a test of the LOP which holds if the null is rejected. Given cointegration, the null of perfect market integration is tested where a price change in one market leads to an equivalent price change in the other; imperfect market integration occurs if the relationship is not strictly proportional.

A price series is often trended and can be made stationary by first-differencing, that is it is integrated of order one, or I(1). In general, the OLS regression in (2) is spurious since it is based on the assumption that both series are stationary (Harris, 1995, p.14). The exception is when (2) is cointegrated where the prices move together so that a stable relationship between them is maintained. Any short-run disturbance away from this relationship induces changes in the prices so that the relationship is maintained in the long run. In this sense, cointegration implies that a meaningful long-run equilibrium exists (Granger, 1988). Since a cointegrating relationship cannot exist between two prices which are integrated of a different order, it is necessary to test for their order of integration. The subsequent test for cointegration is a formal test of the long-run equilibrium relationship between pair-wise prices.

We begin by testing for the presence of unit roots in the individual time series of each model using the augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1981), both with and without a deterministic trend. The number of lags in the ADF-equation is chosen to ensure that serial correlation is absent using the Breusch-Godfrey statistic (Greene, 2000, p.541). If

two prices are integrated of the same order, Johansen's (1988) procedure can then be used to test for the LOP between them. The procedure is based on maximum likelihood estimation of the vector error correction model (VECM):

$$\Delta z_t = \delta + \Gamma_1 \Delta z_{t-1} + \Gamma_2 \Delta z_{t-2} + \Lambda + \Gamma_{p-1} \Delta z_{t-p+1} + \pi z_{t-p} + \Psi x_t + u_t \qquad (3)$$

where z_t is a vector of I(1) endogenous variables, $\Delta z_t = z_t - z_{t-1}$, x_t is vector of I(0) exogenous variables, and π and Γ_i are (n×n) matrices of parameters with $\Gamma_i = -(I - A_1 - A_2 - \ldots - A_i)$, (i=1,…,k-1), and $\pi = I - \pi_1 - \pi_2 - \ldots - \pi_k$. This specification provides information about the short-run and long-run adjustments to the changes in z_t through the estimates of $\hat{\Gamma}_i$ and $\hat{\pi}$ respectively. The term πz_{t-k} provides information about the long-run equilibrium relationship between the variables in z_t. Information about the number of cointegrating relationships among the variables in z_t is given by the rank of the π-matrix: if π is of reduced rank, the model is subject to a unit root; and if 0<r<n, where r is the rank of π, π can be decomposed into two (n×r) matrices α and β, such that $\pi = \alpha\beta'$ where $\beta' z_t$ is stationary. Here, α is the error correction term and measures the speed of adjustment in Δz_t and β contains r distinct cointegrating vectors, that is the cointegrating relationships between the non-stationary variables. Johansen (1988) uses the reduced rank regression procedure to estimate the α- and β-matrices and the trace test statistic is used to test the null hypothesis of at most r cointegrating vectors against the alternative that it is greater than r.

Regression Analysis

Cotton market integration over time may be influenced by various factors i.e. procurement, road length and per capita income. A regression analysis of the following equation is undertaken to analyze the effects of these factors in the cotton market. The functional form of the equation can be written as follows:

$CS = \beta_0 - \beta_1 PROC + \beta_2 ROAD + \beta_3 \qquad (4)$

Where; *CS* = Co integration test statistic in markets; *PROC* = Procurement of seed cotton; *ROAD* = Length of roads in kilometers; and *PCI* = refers to Per capita income.

RESULTS AND DISCUSSIONS

Monthly wholesale prices (Rs./40 kg) of seed cotton from October-February (1992-93) to October-February (2003-04) (60 observations) in logarithmic form are used for this study. The study is confined to six different seed cotton markets of Punjab i.e., Rahim Yar Khan, Multan, Bahawalpur, Okara, D.G.Khan and Vehari. Table 1 reports the unit root results using ADF tests both with and without linear trend. Both models indicate that null of unit root cannot be rejected for all price series as the absolute values of the ADF statistics are well below the 95 percent critical value of the test statistics. We carried out an additional test called the Φ_3 test. The null hypothesis in Φ_3 test is that the variable observed have unit root with no trend against the alternative that the variables are trend stationary. The values of F-statistics for all six variables are below the 95% critical value of the Φ_3 test (7.24); therefore we reject the alternative and accept the null hypothesis that means that all six price series have unit root and no trend.

Table 1. The unit root results

Prices	Trended Model	Non-Trended Model	Φ_3 test
Rahim Yar Khan	-2.45	-1.63	3.27
Multan	-2.15	-1.40	2.52
Bahawalpur	-2.53	-2.19	3.53
Okara	-2.09	-1.40	2.41
D.G. Khan	-3.11	-2.57	5.16
Vehari	-2.15	-1.57	2.43
Critical Value (95% confidence level)	-3.47	-2.90	7.24

The first step of the Johansen procedure is to select the order of the VAR for each price relationship. We use the LR-statistic, adjusted for small samples (Sims, 1980), to test the null hypothesis that the order of the VAR is k against the alternative that it is five where k=0,1,2,…,5 and for all cases, k=1. Johansen's cointegration results are presented in Table 2. The trace test results suggested that these six price series are strongly cointegrated and converge to long run equilibrium in the sense that Punjab seed cotton market system is stationary in four directions and non-stationary in two direction. In other words, four prices can be expressed in terms of the other two prices means that prices in six seed cotton markets are fully cointegrated as law of one price (LOP) holds. It suggests that even though the regional markets are geographically dispersed, and therefore, spatially segmented, spatial pricing relationships reveal that the prices are linked together indicating that all the seed cotton exchange locations are in the same economic market.

Table 3 reports the pair wise relationship between the markets. The results of pair-wise cointegration relationships indicates that Rahim Yar Khan, Multan, Bahawalpur, Okara, Vehari and D.G. Khan seed cotton markets are integrated but not strongly, the pair-wise relationship between (Rahim Yar Khan- Bahawalpur), (Rahim Yar Khan- D.G. Khan), (Multan- Bahawalpur), (Bahawalpur-Okara) and (Bahawalpur-Vehari) show that these markets are not integrated with each other.

Table 2. Co integration Results–Trace Statistics

EEquation Tested	Null	Alternative	Statistics
Rahim Yar Khan, Multan, Bahawalpur, Okara, D.G.Khan, Vehari	r=0 r≤1 r≤2 r≤3 r≤4 r≤5	r≥1 r≥2 r≥3 r≥4 r≥5 r≥6	179.37 (102.56) 126.87 (75.98) 82.89 (53.48) 43.35 (34.87) 11.34(20.18) 4.94 (9.16)

Note: Critical values (95% confidence level) in parentheses.

Table 3. Pair-wise Co integration Results–Trace Statistics

Equation Tested	Null	Alternative	Statistics
Rahim Yar Khan-Multan	r=0 r≤1	r≥1 r≥2	42.51 (20.18) 4.20 (7.53)
Rahim Yar Khan-Bahawalpur	r=0 r≤1	r≥1 r≥2	15.02 (20.18) 5.29 (9.16)
Rahim Yar Khan-Okara	r=0 r≤1	r≥1 r≥2	45.12 (20.18) 4.17 (9.16)
Rahim Yar Khan-D.G.Khan	r=0 r≤1	r≥1 r≥2	19.68 (20.18) 4.28 (9.16)
Rahim Yar Khan-Vehari	r=0 r≤1	r≥1 r≥2	40.19 (20.18) 4.56 (9.16)
Multan- Bahawalpur	r=0 r≤1	r≥1 r≥2	14.87 (20.18) 5.05 (9.16)
Multan- Okara	r=0 r≤1	r≥1 r≥2	39.09 (20.18) 4.15 (9.16)
Multan- D.G.Khan	r=0 r≤1	r≥1 r≥2	22.18 (20.18) 4.05 (9.16)
Multan- Vehari	r=0 r≤1	r≥1 r≥2	44.78 (20.18) 4.90 (9.16)
Bahawalpur- Okara	r=0 r≤1	r≥1 r≥2	13.70 (20.18) 4.73 (9.16)
Bahawalpur- D.G.Khan	r=0 r≤1	r≥1 r≥2	39.79 (20.18) 5.37 (9.16)
Bahawalpur- Vehari	r=0 r≤1	r≥1 r≥2	14.16 (20.18) 4.89 (9.16)
Okara- D.G.Khan	r=0 r≤1	r≥1 r≥2	21.73 (20.18) 3.91 (9.16)
Okara- Vehari	r=0 r≤1	r≥1 r≥2	44.64 (20.18) 4.53 (9.16)
D.G.Khan-Vehari	r=0 r≤1	r≥1 r≥2	24.17 (20.18) 4.34 (9.16)

Note: Critical values (95% confidence level) in parentheses.

Regression analysis of factors influencing seed cotton market integration is conducted using three years moving average procedure. For this purpose, cointegration tests were performed annually for the markets under study for the period of 1992-93 to 2003-04.Cointegration statistics (CS) results using Maximal Eigenvalue test statistics are reported in Table 4. These statistics can be considered as the measure of market integration over time, in which the larger the statistic, the stronger the degree of market integration.

Table 4. Annual Cointegration test result using Maximal Eigenvalue test

Years	CS	CS 3 Years moving avg.
1991	52.50	-
1992	52.12	52.33
1993	52.36	52.31
1994	52.45	52.56
1995	52.87	52.66
1996	52.65	52.64
1997	52.39	52.63
1998	52.85	52.47
1999	52.16	52.59
2000	52.75	52.43
2001	52.37	52.58
2002	52.63	52.60
2003	52.81	-

CS: Cointegration Statistics

The regression analysis results are shown in Table 5. The results indicate that government intervention in terms of seed cotton procurement significantly influenced the degree of market integration, implying that larger the seed cotton procurement, the lower the degree of market integration. These results suggest that procurement programs are less affective in dynamic price adjustment. In addition, road length and per capita income variables are not statistically significant.

Table 5. Regression parameter estimates of factors influencing cotton market integration in Punjab, Pakistan

Variable	Coefficients	t-Value
Intercept	52.182	92.667
Procurement	-0.145	-2.639*
Road	0.000001396	0.425
Per capita income	0.000004377	0.424
R^2	0.642	
Adjusted R^2	0.508	

*Indicates significance at 95% confidence level

SUMMARY AND CONCLUSIONS

In the present study an effort was made to assess the degree of market integration in various seed cotton markets of Punjab province, Pakistan. Cointegration techniques were applied to the monthly wholesale prices data of seed cotton. The results indicated that these seed cotton markets are strongly cointegrated and converge to long run equilibrium in the sense that Punjab seed cotton market system is stationary in four directions and non-stationary in two directions. In other words, four prices can be expressed in terms of the other two prices means that prices in six seed cotton markets are fully cointegrated as law of one price (LOP) holds. The high degree of market integration observed in this case is consistent with view that Punjab's seed cotton markets are quite competitive and provide little justification for extensive and costly government intervention designed to improve competitiveness to enhance market efficiency. The results also indicate that certain pair wise markets are not well integrated with each other. The integration among these markets can be improved through the promotion of price information and communication facilities.

REFERENCES

Alexander, C. and J. Wyeth. 1994. Cointegration and Market Integration: An Application to the Indonesian Rice Market, Journal of Development Studies, 30, 303-328.

Dickey, D.A. and M.A. Fuller. 1981. Likelihood Ration Statistics for Autoregressive time series with a Unit Root, Econometric 49: pp (1057-1072).

Engle, R.F. and C.W.J. Granger. 1987. Cointegration and error correlation. Representation, Estimation and Testing, Econometrica 55: pp (251-276).

Govt. of Pakistan. 2003-04. Economic Survey of Pakistan 2003-04. Finance Division, Economic Adviser's Wing, Islamabad.

Granger, C.W.J. 1988. Some Recent Developments in a Concept of Causality, Journal of Econometrics, 39, 199-211.

Greene, W.H. 2000. *Econometric Analysis*. New Jersey: Prentice-Hall, Inc.

Harris, R. 1995. Using Cointegration Analysis in Econometric Modelling. London: Prentice Hall-Harvester Wheatsheaf.

Johansen, S. 1988. Statistical Analysis of cointegration of vectors, Journal of Economic Dynamic and Control 12: pp 231-254.

Palaskas, T.B. and B. Harriss-White. 1993. The Identification of Market Exogeneity and Market Dominance by Tests Instead of Assumption: An Application to Indian Material, Journal of International Development, 8, 111-123.

Ravallion, M. 1986. Testing market integration, American Journal of Agricultural Economics, 68(2): pp 292-307.

Richardson, J.D. 1978. Some Empirical Evidence of Commodity Arbitrage and the Law of One Price, Journal of International Economics, 8, 341-352.

Sims, C.A. 1980. Macroeconomics and Reality, Econometrica, 48, 1-49.

Tahir, Z. and K. Riaz. 1997. Integration of agricultural commodity markets in Punjab, the Pakistan Development Review. 36(3):241-262.