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Spatial Price Linkages in Regional Onion Markets of Pakistan

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ABSTRACT

This paper evaluates price linkages in spatially separate markets using monthly wholesale real price of onion in four regional markets located in each of the four provinces of Pakistan. Unit root test indicates that the price series in each location are stationary and the series are represented as autoregressive model for each location. The results show that the regional markets of onion have strong price linkages and thus are spatially integrated.

Key Words: Unit root; Spatial integration; Price linkage; Stationarity; Regional onion markets

INTRODUCTION

Spatial price relationship is an important indicator of overall market performance. If price changes in one market are fully reflected in alternative market, these markets are said to be spatially integrated (Goodwin & Schroeder, 1991). In spatially integrated markets, competition among arbitragers will ensure that a unique equilibrium is achieved where local prices in regional markets differ by no more than transportation and transaction costs. Information of spatial market integration, thus, provides indication of competitiveness, the effectiveness of arbitrage, and the efficiency of pricing (Sexton *et al.*, 1991).

Prices in spatially integrated markets are determined simultaneously in various locations and information of any change in price in one market is transmitted to other markets (Gonzalez-Rivera & Helfand, 2001). Markets that are not integrated may convey inaccurate price signal that might distort producers marketing decisions and contribute to inefficient product movement (Goodwin & Schroeder, 1991) and traders may exploit the market and benefit at the cost of producers and consumers. In more integrated markets, farmers specialize in production activities in which they are comparatively proficient, consumers pay lower prices for purchased goods and society is better able to reap increasing returns from technological innovations and economies of scale (Vollrath, 2003).

Market integration of agricultural products has retained importance in developing countries due to its potential application to policy making. Based on the information of the extent of market integration, government can formulate policies of providing infrastructure and information regulatory services to avoid market exploitation.

Agricultural products especially vegetables are very perishable in nature, and are supplied to market within a short time period after harvesting. Onion is one of the most common vegetables in Pakistan and other countries of South Asia. The demand for onion is relatively inelastic in Pakistan, where it is used in cooking with other vegetables and meat in addition to consumed as a salad. Due to its inelastic demand and perishable nature of onion, we observe frequent variations in onion price and trade between regional markets depending on their supply position. Although onion is produced in all of the four provinces of Pakistan, Sindh and Balochistan are the major onion producing provinces. During 2000-01 to 2003-04, average annual onion production in Pakistan was 1.456 million tonnes with 44.4% share from Sindh, 25.4% from Balochistan, 17.0% from Punjab, and 13.2% from North Western Frontier Province (NWFP) (Government of Pakistan, 2005a). Onion is mostly traded from Sindh and Balochistan to the other two provinces. Sometimes, trade also takes place between Sindh and Balochistan and between Punjab and NWFP.

The objective of this paper is to empirically evaluate spatial price linkages among four regional markets of Pakistan using monthly wholesale real prices of onion. First we apply the unit root test to check for the stationarity in price series, and then estimate the price relationship among the regional markets. The rest of the paper is organized as follows. The next section describes data, model, and estimation method followed by a section on results and discussion. Finally, the last section summarizes the results and draws conclusion.

METHODOLOGY

Data. For this study four regional markets including Hyderabad, Lahore, Peshawar, and Quetta were selected as these cities were large primary distributing centers of vegetables in the country, and were taken from each of the four provinces of Pakistan including Sindh, Punjab, NWFP and Balochistan, respectively. Data used in this study were monthly wholesale onion price in rupees (Rs.) from January 1979 to December 2004 published in Agricultural Statistics of Pakistan (Government of Pakistan, 1998a & 2005a). The nominal price data were transformed into real prices by deflating them using the Consumer Price Index (CPI) with base year 2000-01 published in Pakistan Economic Survey (Government of Pakistan, 1998b & 2005b). Since we had monthly price data, we deflated them using monthly CPI series constructed from the annual CPI assuming constant growth rate of the index across the months in a year.

Model. Empirical model for evaluating spatial price linkages used in other studies including Goodwin and Schroeder (1991) is specified as:

$$P_t^1 = \alpha + \beta P_t^2 + \nu_t \qquad (1)$$

where P_t^1 and P_t^2 represent commodity prices of a homogenous good in two alternative regional markets at time *t*, α and β are parameters, and ν_t is the error term. If two markets are perfectly spatially integrated, then $\beta = 1$. In this case, price changes in one market are fully reflected in alternative market. When $\beta \neq 1$ ($\beta < 1$ or $\beta > 1$), then degree of integration is evaluated by investigating how far is the deviation of β from unity.

Estimation method and unit root test. Method for estimating Equation (1) depends on the time series properties of commodity price in each location. If the price series are nonstationary with unit root, the relationship may be estimated as cointegration developed by Granger (1983) and Engle and Granger (1987). However, the price series in this study indicate stationarity, which is checked by unit root test. The classical regression model is appropriate for estimating Equation (1) when price series of both locations are stationary (Enders, 2004). Although this regression model has stochastic regressor, the ordinary least square (OLS) method gives minimum variance linear unbiased estimators by Gauss-Markov Theorem (Greene, 2003). When time series data indicate serial correlation, OLS is consistent but inefficient. In this case, the significance of the coefficient estimates is tested with standard *t* test by using heteroscedasticity and autocorrelation consistent covariance estimator developed by Newey and West (1987). The Newey-West estimator is a robust estimator for the covariance of the OLS estimator, and these estimators constitute the generalized method of moments (GMM) estimator (Greene, 2003).

The OLS method is appropriate for estimating Equation (1) if price series of both locations are stationary. Stationarity of price series is checked by unit root test using Augmented Dickey-Fuller (ADF) test. Data show that real price of onion has no trend and has a positive mean for each location as illustrated in Fig. 1 in the next section. In this case, the null hypothesis (H_0) in the ADF test is unit root autoregression with no drift, and the alternative hypothesis (H_A) is autoregressive model with constant term. As described in Hamilton (1994), the ADF test is carried out by estimating the following equation:

$$P_t = \mu + \phi P_{t-1} + \gamma_1 \Delta P_{t-1} + \gamma_2 \Delta P_{t-2} + \ldots + \gamma_{k-1} \Delta P_{t-k+1} + \varepsilon_t \qquad (2)$$

where P_t is price at time t at a location ΔP_t represents change in the price and is equal to ($P_t - P_{t-1}$), $\mu, \phi, \gamma_1, \gamma_2, \ldots, \gamma_{k-1}$ are parameters, k is the order of autoregressive model, and ε_t is the error term. Using the Augmented Dickey-Fuller test, we test the null hypothesis that $\mu = 0$ and $\phi = 1$.

Under the null hypothesis, Equation (2) is a unit root autoregressive model with no drift, and the time series is nonstationary. The alternative hypothesis is stationary autoregressive model with constant term. The OLS *F* test is performed for testing the joint null hypothesis that $\mu = 0$ and $\phi = 1$. The OLS *F* statistic is computed as follows:

$$F = \frac{(e_*' e_* - e' e)/(P - P_*)}{e' e /(N - P)} \qquad (3)$$

where e_* is vector of residuals from H_0 $e_*' e_*$, is residual sum of squares (RSS) from H_0, and P_* is its number of parameters. Similarly, *e* is vector of residuals from H_A, $e' e$ is RSS from H_A, *P* is its number of parameters, and *N* is the number of sample observations. For this test, the OLS *F* statistic is compared with the critical values provided by Dickey and Fuller (1981) as reported in Hamilton (1994). If the *F* statistic is larger than the critical value, we reject the null hypothesis.

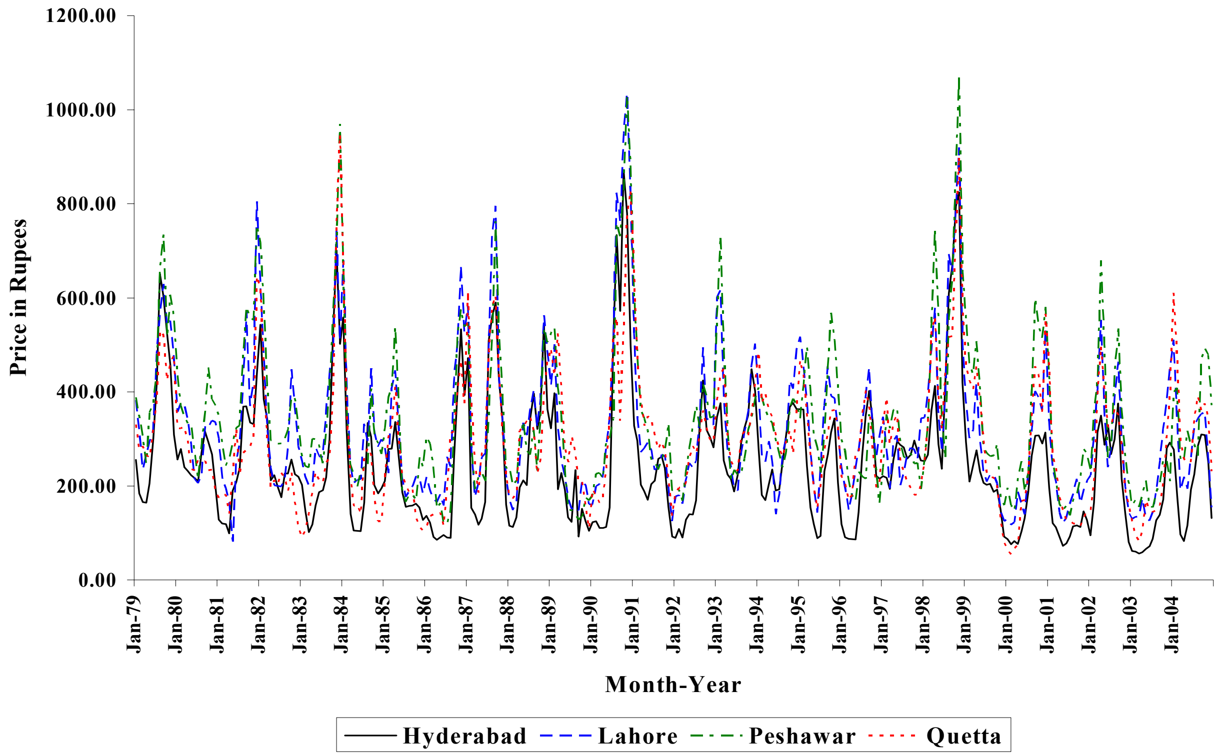
For performing the above unit root test, the order of autoregressive model, *k*, must be specified in estimating Equation (2). The appropriate order of autoregressive model is such that the error term ε_t is a white noise process. The Ljung-Box test is conducted for checking that the error term is a white noise process (Ljung & Box, 1979).

RESULTS AND DISCUSSION

Graphical representation and average price. Graphical representation of monthly wholesale real prices of onion in the four regional markets including Hyderabad, Lahore, Peshawar and Quetta is given in Fig. 1. The fig. shows that the prices in different markets move together. Data indicate a large volatility in onion price in every market and overall no trend in the series. Onion price is volatile across time due to supply shocks, perishable nature of onion, and storage costs. From January 1979 to December 2004, the average price of onion per 40 kg was Rs. 247.14 in Hyderabad, Rs. 320.61 in Lahore, Rs. 345.52 in Peshawar, and Rs. 298.00 in Quetta. The price difference across these markets is mainly due to transportation and transaction costs.

Results of unit root test. The Augmented Dickey-Fuller test is carried out for testing the null hypothesis of unit root autoregressive model with no drift in onion price series against the alternative hypothesis of stationary autoregressive model with constant term. *F* test is performed for testing the null hypothesis. Results of the Augmented

Fig. I. Monthly wholesale real prices of onion from Jan. 1979 to Dec. 2004



Dickey-Fuller test are presented in Table I. The table reports residual sum of squares (RSS), number of parameters, and sample size under the null and alternative hypotheses for the onion regional markets of Hyderabad, Lahore, Peshawar and Quetta. For each of the four locations, the results show that the null hypothesis of unit root is rejected as the *F* statistic is much greater than 6.52, which is the critical value at 1% significance level provided in Dickey and Fuller (1981). Thus, the results indicate that the onion price series in each location represent a stationary autoregressive model with constant term.

Table I. Augmented dickey-fuller test for testing unit root

Market (City)	RSS from H_0	Para-meters in H_0	RSS from H_A	Para-meters in H_A	Sample Size N	F stat.
Hyderabad	2196393	3	1793206	5	308	34.06
Lahore	3121353	1	2653152	3	310	27.09
Peshawar	3050969	1	2516850	3	310	32.58
Quetta	2203287	1	1824828	3	310	31.84

The 5 % critical value is 4.63 and 1 % critical value is 6.52 for each case.

In the Augmented Dickey-Fuller test given above, the order of autoregressive model is determined by checking that the error term is a white noise process using the Ljung-Box test. Onion price is described as autoregressive model of order 4 for Hyderabad and order 2 for Lahore, Peshawar and Quetta. Hence, with the constant term, the unrestricted model has 5 parameters for Hyderabad and 3 parameters for the other three markets given in Table I.

Empirical results of spatial price linkages. Spatial price relationship between spatially separated markets is estimated using the model specified in Equation (1). Given four markets, there are 12 different pairwise relationships, where each market has been regressed with the other market from the remaining three markets. In this way, a total number of 12 regressions are run. The OLS method is used for estimating the coefficients, while for testing the significance of the coefficients, *t* statistics are computed using Newey-West's heteroscedasticity and autocorrelation consistent covariance matrix. Table II presents estimates of the intercept α, slope β, and their *t* statistics, and R^2 of these regressions.

The slope parameter β indicates the relationship between the two markets. If the markets are perfectly spatially integrated, the slope parameter β is one or near to one. The fifth column in Table II reports the estimates of slope parameter β. In the regression of Lahore on Hyderabad the estimated slope parameter is one. This indicates that the price change in Hyderabad is fully reflected in Lahore. A change of Rs. 1.00 in onion price in Hyderabad brings the same change in onion price in Lahore market. The estimated slope parameter β = 0.96 in the regression for Peshawar on Quetta, β = 0.94 for Peshawar on Hyderabad, and β = 0.91 for Lahore on Quetta. These results indicate strong spatial price linkages among markets. In these strong relationships, note that independent variables

Table II. Regression results of spatial price relationship in onion markets

Dependent variable (Price in market)	Independent variable (Price in market)	Intercept α		Slope β		R^2
		Estimate	*t* statistics	Estimate	*t* statistics	
Hyderabad	Lahore	-20.26	-1.67	0.83	21.42	0.84
Hyderabad	Peshawar	-2.65	-0.18	0.72	16.24	0.68
Hyderabad	Quetta	9.87	0.60	0.80	12.91	0.64
Lahore	Hyderabad	72.58	7.81	1.00	25.01	0.84
Lahore	Peshawar	29.92	1.92	0.84	18.00	0.77
Lahore	Quetta	50.08	2.72	0.91	13.41	0.69
Peshawar	Hyderabad	112.69	10.90	0.94	19.79	0.68
Peshawar	Lahore	53.42	4.90	0.91	24.54	0.77
Peshawar	Quetta	60.75	3.84	0.96	18.12	0.70
Quetta	Hyderabad	100.07	6.70	0.80	14.62	0.64
Quetta	Lahore	54.70	3.18	0.76	14.19	0.69
Quetta	Peshawar	43.14	2.59	0.74	17.31	0.70

The 5 % critical value is 1.96 and 1 % critical value is 2.576 for t test in each case.

are prices in Hyderabad and Quetta, and the dependent variables are prices in Lahore and Peshawar. Hyderabad and Quetta are the large markets from the major onion producing provinces, Sindh and Balochistan, respectively and supply to Lahore and Peshawar markets. Thus, these results show strong relationship between the markets where most of the trade takes place.

When there is short supply either in Quetta or Hyderabad, trade also takes place between them. A small quantity of onion is also transported to Lahore from Peshawar during the production period of onion in Sawat division of NWFP province. Regression results indicate spatial price linkages with $\beta = 0.91$ for Peshawar on Lahore, and $\beta = 0.80$ between Hyderabad and Quetta. Thus, empirical results reveal that onion trading markets are spatially integrated as indicated by strong spatial price linkages among markets where most of the trade take place, and overall high spatial price linkages among major onion trading markets.

CONCLUSION

Spatial market integration is examined by estimating price linkages among geographically separate onion markets of Pakistan. Data used for the analysis are monthly wholesale real price in four regional markets namely Hyderabad, Lahore, Peshawar and Quetta cities, which are taken from each of the four provinces of Pakistan including Sindh, Punjab, NWFP and Balochistan, respectively. For each location, the units root test indicates that the price series are stationary, and the series are represented as autoregressive model. Spatial price linkages between locations are evaluated by estimating parameters with OLS method and testing their significance using Newey-West's heteroscedasticity and autocorrelation consistent covariance matrix.

Hyderabad and Quetta are from the major onion producing provinces, Sindh and Balochistan, respectively, and supply to Lahore and Peshawar markets. Results reveal that onion trading markets are spatially integrated as indicated by strong spatial price linkages among markets.

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