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Testing Onion Market Integration in Pakistan

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I. INTRODUCTION

Spatial market integration of agricultural products has been widely used to indicate overall market performance [Faminow and Benson (1990)]. 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)].

If price changes in one market are fully reflected in alternative market, these markets are said to be spatially integrated [Goodwin and Schroeder (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 and 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 and Schroeder (1991)], and traders may exploit the market and benefit at the cost of producers and consumers. In more integrated markets, farmers specialise 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

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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 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 percent share from Sindh, 25.4 percent from Balochistan, 17.0 percent from Punjab, and 13.2 percent from North Western Frontier Province (NWFP) [Pakistan (2005)]. 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 analyse spatial market integration 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 using the error correction model. The rest of the paper is organised as follows. Section II describes data used in this study. Section III specifies the error correction model. Estimation method and unit root test are described in Section IV followed by sections on the results of the study. Finally, the last section draws conclusion.

II. DATA

For this study four regional markets including Hyderabad, Lahore, Peshawar, and Quetta are selected, as these cities are large primary distributing centres of vegetables in the country, and are taken from each of the four provinces of Pakistan including Sindh, Punjab, NWFP, and Balochistan, respectively. Data used in this study are monthly wholesale onion price in rupees (Rs) from January 1979 to December 2004 published in *Agricultural Statistics of Pakistan* [Pakistan (1998, 2005)]. The nominal price data are transformed into real prices by deflating them using the Consumer Price Index (CPI) with base year 2000-01 published in *Pakistan Economic Survey* [Pakistan (1998a, 2005a)]. Since nominal onion price data are monthly time series, these data are deflated using monthly CPI series constructed from the annual CPI assuming a constant growth rate of the index across the months in a year. This assumption makes a smooth index during a year, and is appropriate because the farmers make production decisions on an annual basis.

Data of monthly wholesale real prices of onion in the four regional markets including Hyderabad, Lahore, Peshawar, and Quetta are plotted in Figure 1 in Appendix A. 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 wholesale real price of onion per 40 kilogram 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.

III. THE MODEL

If geographically separated markets are integrated, then there exists an equilibrium relationship among these markets [Gonzalez-Rivera and Helfand (2001); Goodwin and Schroeder (1991); Sexton, *et al.* (1991)]. The long-run equilibrium relationship for analysing market integration used in the previous studies [e.g. Goodwin and Schroeder (1991)] is specified as:

$$P_t^1 = \alpha + \lambda P_t^2 \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \qquad (1)$$

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

The long-run relationship in Equation (1) may not satisfy at each time period. For investigating the short-run and long-run relationships, the error correction model representation of Equation (1) is specified as:

$$\Delta P_t^1 = \beta_0 + (\beta_1 - 1)(P_{t-1}^1 - \alpha - \lambda P_{t-1}^2) + \gamma_0 \Delta P_t^2 + u_t \quad \dots \quad \dots \qquad (2)$$

where $0 < \beta_1 < 1$ and ΔP_t^i represents change in the price at location $i = 1, 2$. In this model, $(P_{t-1}^1 - \alpha - \lambda P_{t-1}^2)$ measures the extent to which the long-run relationship is not satisfied at time period t–1. The parameter (β_1 – 1) is interpreted as the proportion of the resulting disequilibrium adjusted in the next period. Therefore, the term $(\beta_1 - 1)(P_{t-1}^1 - \alpha - \lambda P_{t-1}^2)$ is the error correction term. When β_1 is close to 1, the speed of adjustment to long-run equilibrium is very slow. When β_1 is close to 0, the speed of adjustment is very fast.

IV. ESTIMATION METHOD AND UNIT ROOT TEST

IV.1. Estimation Method

For describing the method of estimating the error correction model specified in Equation (2), denote:

$$y_t = P_t^1$$

$$x_t = P_t^2$$

Then Equation (2) can be written as:

$$\Delta y_t = \mu + (\beta_1 - 1)(y_{t-1} - \lambda x_{t-1}) + \gamma_0 \Delta x_t + \varepsilon_t \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

where $\mu \equiv \beta_0 - \alpha(\beta_1 - 1)$. The method for estimating Equation (3) depends on the time series properties of commodity price in each location. If the price series are non-stationary 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 described in Section 4.2.

As the price series are stationary, the model in Equation (3) is the error correction model in the presence of stationarity. Although Equation (3) is nonlinear in parameters, its reparametrisation yields linear equation [Davidson and MacKinnon (2004), p. 579)]. Denote:

$$\lambda \equiv \frac{\gamma_0 + \gamma_1}{1 - \beta_1} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

Then, Equation (3) can be written as:

$$y_t = \mu + \beta_1 y_{t-1} + \gamma_0 x_t + \gamma_1 x_{t-1} + \varepsilon_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

The model in Equation (5) is an autoregressive distributed lag (ADL) model. The classical regression model is appropriate for estimating Equation (5) when both variables are stationary [Enders (2004)]. As lagged dependent variable is a regressor in the Equation (5), the regressors are only contemporaneously independent of the error term, and are not independent of the error term at each time period. In this case, the OLS estimator may give biased estimates. However, the bias disappears as sample size becomes larger. Therefore, the OLS estimator can be justified asymptotically [Hamilton (1994), p. 215]. The estimates of Equation (5) can be used to find point estimates of parameters in Equation (3) using Equation (4).

The method described above provides point estimates of parameters of nonlinear Equation (3). For estimating the covariance matrix of the estimates of Equation (3), the Gauss-Newton regression (GNR) method is used as suggested by Davidson and MacKinnon (2004, p. 579). By GNR approach, we specify following regression:

$$\hat{\varepsilon}_t = X_{p,t} b + \nu_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

where $\hat{\varepsilon}_t$ is the residual from Equation (3) (or from Equation (5)) at each t, $X_{p,t}$ is a vector of partial derivative of nonlinear regression function in Equation (3) with respect to its parameters at each t, and ν_t is the error term. Equation (6) is estimated by the OLS method, which will yield $\hat{b} = 0$ and can have no explanatory power. The interest of running this regression is to estimate the variance of b, $\hat{V}ar(\hat{b})$. Davidson and MacKinnon (2004, p. 239) show that $\hat{V}ar(\hat{b})$ is identical to the variance of parameter estimates of Equation (3).

As time series data are used, there may be serial correlation. So, in the GNR method, we estimate 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 generalised method of moments (GMM) estimator [Greene (2003)].

IV.2. Unit Root Test

The above estimation method is appropriate if the price series of the 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 Figure 1 in Appendix A. 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:

$$P_t = \delta + \phi P_{t-1} + \theta_1 \Delta P_{t-1} + \theta_2 \Delta P_{t-2} + ... + \theta_{k-1} \Delta P_{t-k+1} + e_t \qquad \ldots \qquad (7)$$

where P_t is price at time t at a location, ΔP_t represents change in the price and is equal to $(P_t - P_{t-1})$, $\delta, \phi, \theta_1, \theta_2, ..., \theta_{k-1}$ are parameters, k is the order of autoregressive model, and e_t is the error term. Using the Augmented Dickey-Fuller test, we test the null hypothesis that $\delta = 0$ and $\phi = 1$.

Under the null hypothesis, Equation (7) is a unit root autoregressive model with no drift, and the time series is non-stationary. The alternative hypothesis is stationary autoregressive model with constant term. The OLS *F*-test is performed for testing the joint null hypothesis that $\delta = 0$ and $\phi = 1$. The OLS *F*-statistic is computed as follows:

$$F = \frac{(\hat{e}_*'\hat{e}_* - \hat{e}'\hat{e})/(K - K_*)}{\hat{e}'\hat{e}/(N - K)} \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (8)$$

where $\hat{e}_*$ is vector of residuals from H_0, $\hat{e}_*'\hat{e}_*$ is residual sum of squares (RSS) from H_0, and K_* is its number of parameters. Similarly, $\hat{e}$ is vector of residuals from H_A, $\hat{e}'\hat{e}$ is RSS from H_A, K 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 (7). 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 and Box (1979)].

V. 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 Dickey-Fuller test are presented in Table 1. 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 percent significance level provided in Dickey and Fuller (1981). Thus, the results indicate that the onion price series in each location represents a stationary autoregressive model with constant term.

Table 1

Augmented Dickey-Fuller Test for Testing Unit Root

Market (City)	RSS from H_0	Parameters in H_0	RSS from H_A	Parameters 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 percent critical value is 4.63 and 1 percent 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 1.

VI. EMPIRICAL RESULTS OF MARKET INTEGRATION

Spatial market integration is analysed by estimating the price relationship between spatially separated markets specified in Equation (3). 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. Table 2 presents estimates of parameters of Equation (3) including μ, β_1, γ_0, and λ, their *t* statistics, and R^2 of these regressions. In this model, μ is intercept, β_1 is parameter that measures the speed of adjustment to long-run equilibrium, γ_0 is slope on Δx_t, λ is market integration parameter.

If the two markets are perfectly spatially integrated, the parameter λ is one or near to one. In the regression of Quetta on Hyderabad, the estimated value of λ is one. This indicates that the price change in Hyderabad is fully reflected in Quetta. A change of Rs 1.00 in onion price in Hyderabad brings the same change in onion price in Quetta market. The estimated parameter $\lambda = 0.97$ in the regression for Peshawar on Quetta, $\beta = 0.95$ for Quetta on Lahore, and $\beta = 1.06$ for Lahore on Hyderabad. These results indicate strong spatial market integration among markets.

Hyderabad and Quetta are the large markets from the major onion producing provinces, Sindh and Balochistan, respectively, and supply to Lahore and Peshawar markets. When there is short supply either in Quetta or Hyderabad, trade also takes place between them. Thus, the model results show strong relationship between the markets where most of the trade takes place. Also, note that, in these regressions, independent variable is Quetta or Hyderabad, as these markets are onion suppliers.

The model results of the other regressions also show high spatial markets integration. 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.

Table 2 also presents the estimates of adjustment parameter β_1. When β_1 is close to 1, the speed of adjustment to long-run equilibrium is very slow. When β_1 is close to 0, the speed of adjustment is very fast. The model results in Table 2 show that the estimated parameter ranges from 0.44 to 0.71, indicating a moderate speed of adjustment to long-run equilibrium.

VII. 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 the error correction model in the presence of stationarity.

Table 2

Regression Results of Spatial Price Relationship in Onion Markets

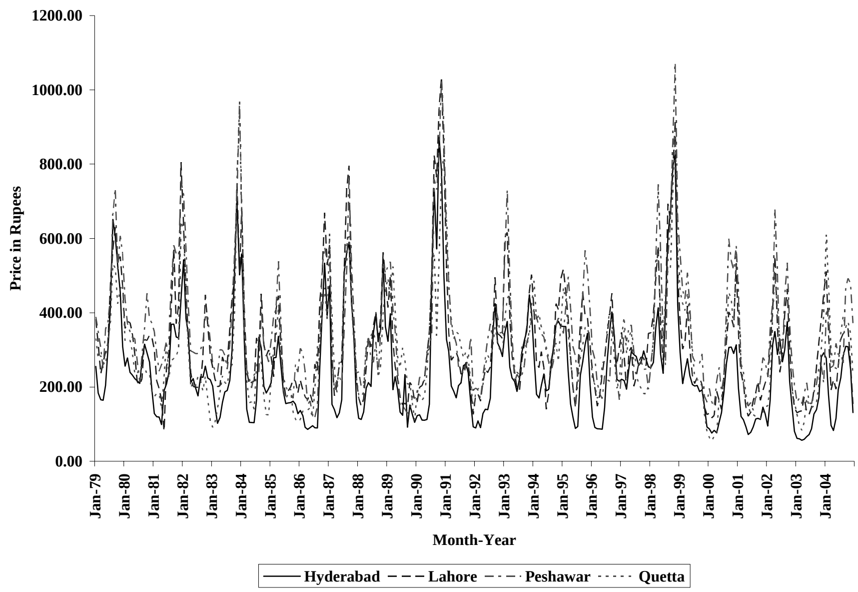
Dependent Variable (Price in Market)	Independent Variable (Price in Market)	Intercept μ		Adjustment Parameter β_1		Slope on Δx_t γ_0		Market Integration Parameter λ		
		Estimate	*t* statistics	Estimate	*t*-statistics	Estimate	*t*-statistics	Estimate	*t*- statistics	R^2
Hyderabad	Lahore	–6.37	–0.80	0.53	8.50	0.71	12.69	0.81	14.94	0.88
Hyderabad	Peshawar	24.74	2.89	0.68	11.15	0.57	9.58	0.49	4.94	0.80
Hyderabad	Quetta	20.67	1.95	0.71	15.53	0.65	9.43	0.59	4.33	0.80
Lahore	Hyderabad	33.13	3.73	0.44	8.00	0.89	21.34	1.06	18.71	0.87
Lahore	Peshawar	37.22	3.93	0.56	6.28	0.79	13.09	0.68	8.33	0.84
Lahore	Quetta	39.49	3.91	0.64	8.86	0.84	10.50	0.70	6.40	0.81
Peshawar	Hyderabad	26.10	2.84	0.53	8.65	0.66	10.57	1.17	19.45	0.83
Peshawar	Lahore	–2.67	–0.31	0.49	6.94	0.68	13.30	1.09	20.27	0.87
Peshawar	Quetta	19.35	2.19	0.65	14.13	0.83	14.97	0.97	10.50	0.83
Quetta	Hyderabad	18.59	2.22	0.64	13.76	0.61	10.58	1.00	10.46	0.82
Quetta	Lahore	–2.84	–0.32	0.62	11.70	0.58	13.54	0.95	12.02	0.85
Quetta	Peshawar	12.50	1.33	0.67	15.78	0.62	11.94	0.75	9.23	0.84

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

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.

APPENDIX A

Fig. 1. Monthly Wholesale Real Prices of Onion from Jan. 1979 to Dec. 2004



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Comments

The paper analyses spatial market integration using monthly wholesale real price of onion in four regional markets. Unit root test indicates that price series in each location i.e. Hyderabad, Quetta, Lahore and Peshawar are stationary and the series are represented as auto regressive model also for each location. The results of error correlation model revealed that onion trading markets are spatially integrated as indicated by strong price linkages among markets.

This is a well-structured paper on a vital issue of marketing as there is scanty information available to guide policy-makers. In this way, the researchers have made a significant contribution to the existing literature on market integration analysis.

I really appreciate author's readings and recourse to different good sources/ references. Using this opportunity, I wish to make the following comments:

> The authors used monthly onion price data and deflated it by annual Consumers Price Index (CPI) series assuming constant growth rate index across the months in a year. The monthly CPI in major cities is available. It will be better, if these series would be used on monthly data sets, separately, for each market.

Moreover, onion prices are sensitive on daily basis than the monthly basis and if deflating it on yearly CPI will generate biased effects. This is important because many developments have taken place in the agricultural marketing sector in Pakistan e.g. introduction of better and cheap communication facilities, cellular phone—now the price information is frequently exchanged among traders, beoparies, and commission agents. Even the truck drivers possess mobile phones and their direction of movement can be redirected, with the change in price, from one market to another.

The roads and railway tracks are greatly improved overtime. Now we have motor ways, highways, link roads, fast moving electric trains, etc. which have greatly facilitated in rapid assembling and distribution of commodity in the country. There is a significant demand from conventional Bedford trucks to 10 to 12 wheel big truck and trailers in goods transport sector.

Instead of monthly prices, if author's uses weekly or even daily price data the sample size would become very large, resulting in reduction bias of OLS estimates. In this connection the researchers can get this information from district market committees rather than sorting the published statistics.

The variables chosen for the analysis are conventional. There is a need to incorporate variables like total production of commodity reaching the resource market and developments in the marketing and transport sectors.

The authors used Hyderabad market instead of Karachi. Karachi has the largest fruit and vegetable market in the country. It has maximum storage facility and capacity. Being a mega city, it also consumes large amount of onion.

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