©The Pakistan Development Review
46 : 4 Part II (Winter 2007) pp. 1075–1084

Price Integration in Wholesale Maize Markets in Pakistan

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1. INTRODUCTION

Continuing debate concerning the appropriate role of the government in the marketplace and the necessity to some how estimate the effects of agricultural policies on agricultural markets have forced researchers to develop various methods, which would enable them to analyse market efficiency. Government intervention in setting prices, incomes and markets is always controversial. For economists, government intervention may be justified if it does not enhance distortions into the market and, moreover, remedies the existing market imperfections. But how can one observe whether the policy proves to improve market functioning or results in even more inefficiency? One way to throw some light on this long-standing issue is to analyse market performance by studying market integration.

Three types of market integration are identified in the literature, which are inter-temporal, vertical and spatial. Inter-temporal market integration relates to the arbitrage process across periods. Vertical market integration is concerned with stages in marketing and processing channels. Spatial integration is concerned with the integration of spatially distinct markets i.e. if price changes in one market are fully reflected in alternative market then these markets are said to be spatially integrated. The concept of market integration has normally been applied in studies involving spatial market inter-relatedness.

Market integration is a central issue in many contemporary debates concerning the issues of market Liberalisation. Market integration is perceived as a precondition for effective market reforms in developing countries. The high degree of market integration means the markets are quite competitive and provide little justification for extensive and costly government intervention designed to improve competitiveness to enhance market efficiency. Markets that are not integrated may convey inaccurate picture about price information that might distort production decisions and contribute to inefficiencies in markets, harm the ultimate consumer and lead to low production and sluggish growth, specifically in rural economy that is the lynchpin of the most of the developing countries including Pakistan.

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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 for providing infrastructure and information regulatory services to avoid market exploitation.

After wheat and rice, maize is the third most important cereal crop in Pakistan. Maize occupies around 5 percent of the total cropped area and 8 percent of the total area under food crops. Its production grew at an annual rate of nearly 5 percent from 1990-91 to 2005-06. Maize is grown in all over Pakistan but Punjab and North West Frontier Province (NWFP) dominate in its Production. During 2000-01 to 2005-06, average annual maize production in Pakistan was 2141.43 thousands tons with 54 percent and 45 percent share from Punjab and NWFP respectively [*Economic Survey (2005-06)*]. In the past, maize was a subsistence crop and the farmers held most of their production for their regular diet, seed, livestock, etc. With increasing real national income, urbanisation, shift in consumption patterns in favour of wheat, rice, meat, diary, fruits and vegetables, and introduction of new maize products, maize producers created a surplus for the industry. Presently, 30 to 35 percent of the national production of maize is market surplus to be used in the industry. More than half of industry's share is used in the wet- milling industry to produce starch, sweeteners, corn oil, glucose, custard powder and gluten. The rest almost half share of the industry is consumed by the poultry industry for manufacturing feed. As only a small amount of maize is consumed in Punjab, therefore, there is a huge market surplus in this province. Most of this market surplus is traded with other provinces. Whereas, in NWFP much of maize is used for farmers' home consumption and only a small amount is available to sale in the market.

The objective of this paper is to analyse the degree of market integration among four main regional maize markets of Pakistan. Following Ravallion (1986), we assume a radial market structure where there is a group of local, regional markets and a central market in Lahore, that is not only the capital city of Punjab province but also is a major centre for business and trade. The regional markets chosen are those in Hyderabad, Peshawar, and Quetta. These regional markets are located in Sindh, NWFP and Balochistan provinces respectively. Trade between regional markets may exist but trade with the central market dominates price formation and accordingly we assume the three pair-wise price relationships i.e. between the price in Lahore and those in the regional markets.

The rest of the paper is organised as follows. Section 2 provides literature review. Analytical framework is presented in Section 3. Data description and empirical findings are given in Section 4. The final section concludes the study.

2. LITERATURE REVIEW

The issue of market integration in many agricultural commodities has figured prominently in empirical research mainly because of its significance for market liberalisation and price policy. For example, the study of the relationship between prices of food grains makes its possible to identify groups of integrated markets so that unnecessary government intervention in the food markets may be avoided. The integration of food markets enhances regional food security by ensuring regional balance among food-deficit, food-surplus and non-food cash crop-producing regions. When, however, food markets are not integrated, local food scarcity will persist, as localised deficient markets fail to send the right signals to the surplus markets to attract supplies of food grains. Moreover, the study of market integration offers a clear picture of the process of transmission of incentives across marketing chains. Market integration is, therefore, a precondition for the success of price policy and market liberalisation programmes [Ghosh (2003)].

Since testing for market integration is central to the design of an agricultural price policy in large developing countries and has been an area of abiding research interest. Baulch (1997) identifies four econometric approaches for measuring spatial market integration, namely, law of one price (LOP), the Ravallion model, Granger-causality and cointegration tests. Dawson and Dey (2002) propose an integrated empirical framework which tests for long-run spatial market integration between price pairs using a dynamic vector autoregressive (VAR) model and cointegration technique. Hypotheses tests of market integration, perfect market integration and causality are conducted sequentially. The approach is illustrated using monthly prices from rice markets in Bangladesh since trade liberalisation of 1992. Results show that rice markets are perfectly integrated and that Dhaka dominates near markets but is dominated by more distant markets. Jha, *et al.* (2005) examine market integration in 55 wholesale rice markets in India using monthly data over the period January 1970 to December 1999. The technique of Gonzalez-Rivera and Helfand (2001) has been used to identify common factors across various markets. It is discovered that market integration is far from complete in India and a major reason for this is the excessive interference in rice markets by government agencies. As a result, it is hard for scarcity conditions in isolated markets to be picked up by markets with abundance in supply. A number of policy implications are also considered. Bakhshoodeh and Sahraeiyan (2006) study integration of major Iranian agricultural product markets using the Engle-Granger cointegration technique and Ravallion test applied to 1984-2002 price data. The typical results show that although long-run market integration exists among local markets of products such as rice and wheat, Iran's major agricultural product markets are not integrated with world markets in the long-run. Government interventions were recognised as the major impediments to domestic and world market integrations.

However, in Pakistan, the literature on agricultural market integration is acutely scarce. The only studies that we have come across are Lohano and Mari (2006) and Mushtaq, *et al.* (2006). The former study analyses spatial market integration using monthly wholesale real price of onion in four regional markets located in each of the four provinces of Pakistan. The results obtained from the error-correction model show that the regional markets of onion have strong price linkages and thus are spatially integrated. While Mushtaq, *et al.* (2006) have used monthly wholesale price data from January 1995 to December 2003 of Basmati Rice and empirically estimated the degree of integration in rice (Basmati) markets of Punjab using the law of one price (LOP) framework and cointegration analysis. The findings of the study indicate that rice markets are highly integrated in the long run. The significance of the present study is to test the market integration of domestic maize markets since it is the third most important cereal crop in Pakistan.

3. ANALYTICAL FRAMEWORK

For price integration, simple bivariate correlation coefficients measure the price movements of a commodity in different markets. This is the simplest way to measure the spatial price relationships between two markets. Early inquiries on spatial market integration, for example Lele (1967) and Jones (1968) have used this method. However, this method clearly has some limitations, as it cannot measure the direction of price integration between two markets. The cointegration procedure measures the degree of price integration and takes into account the direction of price integration. This econometric technique provides more information than the correlation procedure, as it allows for the identification of both the integration process and its direction between two markets.

The present study uses a two-step research procedure. In the first step, market integration is tested to examine a stable relationship between markets. If markets are found to be integrated then the analysis moves to the second step in which a Granger-causality test is applied to discover the direction of influences between the markets.

3.1. Market Integration Test

Market integration is tested using the cointegration method, which requires that:

- Two variables, say P_{it} and P_{jt} are non-stationary in levels but stationary in first differences i.e. $P_{it} \sim I(1)$ and $P_{jt} \sim I(1)$.
- There exists a linear combination between these two series, which is stationary i.e. $\upsilon_{it}(= P_{it} - \hat{\alpha} - \hat{\beta} P_{jt}) \sim I(0)$.

So the first step is to test whether each of the univariate series is stationary. If they are both $I(1)$ then we may go to the second step to test cointegration. The Engle and Granger (1987) procedure is the common way to test cointegration.

Augmented Dickey Fuller (ADF) test [Dickey and Fuller (1981)] is usually applied to test stationarity. It tests the null hypothesis that a series (P_t) is non-stationary by calculating a t-statistics for $\beta = 0$ in the following equation:

$$\Delta P_t = \alpha + \beta P_{t-1} + \gamma t + \sum_{k=2}^{n} \delta_k \Delta P_{t-k} + \varepsilon_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Where $\Delta P_t = P_t - P_{t-1}$, $\Delta P_{t-k} = P_{t-k}, P_{t-k-1}$ and $k = 2,3,\ldots..,n$ and where P_t, P_{t-1}, P_{t-k} and P_{t-k-1} are the prices at time t, $t-1$, $t-k$ and $t-k-1$respectively. While α, β, γ and δ are the parameters to be estimated, t captures time trend and ε_t is white noise error term.

If the value of the ADF statistic is less than the critical value at the conventional significance level (usually the five per cent significant level) then the series (P_t) is said to stationary and vice versa. If P_t is found to be non-stationary then it should be determined whether P_t is stationary at first differences i.e. $\Delta P_t(=P_t - P_{t-1}) \sim I(0)$ by repeating the above procedure. If the first difference of the series (ΔP_t) is stationary then the series (P_t) may be concluded as integrated of order one that is $P_{t-1} \sim I(1)$. Now we can move to the second step to check cointegration.

In order to test cointegration, we will apply two-step residual based test of Engle and Granger (1987). In the first step we apply OLS to the following regression equation in which all variables are found to be integrated of same order (e.g. $I(1)$).

$$P_{it} = \rho_1 + \rho_2 P_{jt} + \upsilon_{it} . \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (2)$$

Where P_{it} is the price in market i at time t, P_{jt} is the price in market j at time t, ρ_1 and ρ_2 are parameters to be estimated and υ_{it} are the white noise error terms.

The second step involves testing whether the residual terms υ_{it} from the cointegrating regressions are non-stationary using a modified ADF test

$$\Delta\upsilon_t = \vartheta\upsilon_{t-1} + \sum_{k=2}^{n} \theta_k \Delta\upsilon_{t-k} + \mu_t . \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (3)$$

Where υ_t, υ_{t-1}, υ_{t-k} and υ_{t-k-1} are, respectively, residuals at time t, $t-1$, $t-k$ and $t-k-1$. And where ϑ and θ are parameters to be estimated while u_t is the residual term.

The constant and time trend are omitted from the ADF test because the residual from the cointegrating regression will have a zero mean and be de-trended. The null hypothesis of $\vartheta = 0$ is tested to check the stationarity of the residual. If the value of t-statistic of the ϑ coefficient is less than the critical value then the null hypothesis of non-stationarity is rejected and the residual is found to be stationary at levels. This, in turn, leads to the conclusion that long-run cointegration holds between two time-series.

3.2. Error Correction Model (ECM)

If price series are I (1), then one could run regressions in their first differences. However, taking first differences results in loss of the long-run relationship that is stored in the data. This implies that one needs to use variables in levels as well. Advantage of the Error Correction Model (ECM) is that it incorporates variables both in their levels and first differences. By doing this, ECM captures the short-run disequilibrium situations as well as the long-run equilibrium adjustments between prices. Even if one demonstrates market integration through cointegration, there could be disequilibrium in the short-run i.e. price adjustment across markets may not happen instantaneously. It may take some time for the spatial price adjustments. ECM can incorporate such short-run and long-run changes in the price movements.

An ECM formulation, which describes both the short-run and the long-run behaviours of prices, can be formulated as:

$$\Delta P_{it} = \gamma_1 + \gamma_2 \Delta P_{jt} - \pi\hat{\upsilon}_{it-1} + \nu_{it} . \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (4)$$

In this model, γ_2 is the impact multiplier (the short-run effect) that measures the immediate impact that a change in P_{jt} will have on a change in P_{it}. On the other hand, π is the feedback effect or the adjustment effect that shows how much of the disequilibrium is being corrected, that is the extent to which any disequilibrium in the previous period effects any adjustment in the P_{it} period. Of course $\hat{\upsilon}_{t-1} = P_{it-1} - \hat{\rho}_1 - \hat{\rho}_2 P_{jt-1}$ and therefore from this equation we also have ρ_2 being the long-run response.

3.3. Granger Causality Test

If a pair of series is cointegrated then there must be Granger-causality in at least one direction, which reflects the direction of influence between series (in our case prices). Theoretically, if the current or lagged terms of a time-series variable, say P_{jt}, determine another time-series variable, say P_{it}, then there exists a Granger-causality relationship between P_{jt} and P_{it}, in which P_{it} is Granger caused by P_{jt}. Bessler and Brandt (1982) firstly introduced this test into research on market integration to determine the leading market. From the above analysis, the model is specified as follows:

$$\Delta P_{it} = \theta_{11}\Delta P_{it-1} + \ldots + \theta_{1n}\Delta P_{it-n} + \theta_{21}\Delta P_{jt-1} + \ldots + \theta_{2n}\Delta P_{jt-n} - \gamma_1 (P_{it-1} - \alpha P_{jt-1} - \delta) + \varepsilon_{1t}, \quad \ldots \quad (5)$$

$$\Delta P_{jt} = \theta_{31}\Delta P_{jt-1} + \ldots + \theta_{3n}\Delta P_{jt-n} + \theta_{41}\Delta P_{it-1} + \ldots + \theta_{4n}\Delta P_{it-n} . - \gamma_2 (P_{it-1} - \alpha P_{jt-1} - \delta) + \varepsilon_{2t} \quad \ldots \quad (6)$$

The following two assumptions are tested using the above two models to determine the Granger causality relationship between prices.

$\theta_{21} = \Lambda = \theta_{2n} = \Lambda = \gamma_1 = 0$ (no causality from P_{jt} to P_{it})

$\theta_{41} = \Lambda = \theta_{4n} = \Lambda = \gamma_2 = 0$ (no causality from P_{it} to P_{jt})

4. DATA, ESTIMATION, AND INTERPRETATION OF RESULTS

The price data of this study consist of monthly wholesale prices of maize (Rs/ton) for Lahore (LHR) and three regional markets; namely, Hyderabad (HYD), Peshawar (PESH), and Quetta (QTA) for the period January 1995 to December 2005. Crude data have been obtained from various issues of *Agricultural Statistics of Pakistan,* Government of Pakistan. The selection of these four regional markets has been made primarily to represent all the four provinces of Pakistan. Furthermore, reliable monthly maize price data are not available for any other regional market.

Our empirical analysis begins by investigating the stochastic properties of four price series of maize that is we determine their order of integration. For cointegration to hold all prices need to be integrated of the same order. Usually prices are found to be $I(1)$ or their first difference is $I(0)$. If prices are integrated of different order, no cointegration exists because at least one of the series contains explosive components. To check for the order of integration we apply Augmented Dickey-Fuller (ADF) test on three wholesale price series of maize. Table 1 reports the results. All the series are found to be non-stationary at levels and stationary at first difference. Thus, all price series are shown to be integrated of order one i.e. $I(1)$. Now we can proceed for congregation analysis between wholesale prices of maize at Lahore and in each regional market. For this purpose we run regression Equation (2) using OLS. Table 2 provides the estimated results. If the two markets are perfectly spatially integrated, the parameter ρ_2 in Equation (2) is one or close to one. In the regression of price in Hyderabad on price in Lahore the estimated value of ρ_2 is 0.83. This indicates that a change of rupee one in maize price in Lahore market brings a change of rupee 0.83 in maize price in Hyderabad. Thus high spatial market

Table 1

Augmented Dickey Fuller (ADF) Unit Root Tests

Variables	Level	First Difference	Mackinnon Critical Values for Rejection of Hypothesis of a Unit Root			Decision	Order of Integration
			1 %	5 %	10 %		
ln(HYD)	0.587	–12.182	–2.583	–1.94	–1.62	Non-stationary at level but stationary at first difference	*I* (1)
ln(LHR)	0.480	–9.761	–2.583	–1.94	–1.62	Non-stationary at level but stationary at first difference	*I* (1)
ln(PESH)	0.609	–9.484	–2.583	–1.94	–1.62	Non-stationary at level but stationary at first difference	*I* (1)
ln(QTA))	1.368	–8.830	–2.583	–1.94	–1.62	Non-stationary at level but stationary at first difference	*I* (1)

Note: ln (HYD)= Natural log of wholesale price of maize at Hyderabad market (Rs/ton).
ln (LHR) = Natural log of wholesale price of maize at Lahore market (Rs/ton).
ln (PESH)) = Natural log of wholesale price of maize at Peshawar market (Rs/ton).
ln (QTA)) = Natural log of wholesale price of maize at Quetta market (Rs/ton).

Table 2

Empirical Findings of the Model

Variables	ln(HYD)	ln(PESH)	ln(QTA)
Constant	5.626	2.189	3.598
	(18.572)*	(5.650)*	(6.071)*
ln(LHR)	0.832	0.681	0.779
	(4.760)*	(4.330)*	(11.431)*
AR(1)	0.908		
	(17.628)*		
MA(1)	0.921		
	(20.618)*		
R^2	0.911	0.944	0.929
$\overline{R}^2$	0.900	0.933	0.923
DW	2.046	1.991	1.999
F-Stat	403.677	714.291	412.434
Prob(F-Stat)	0.0000	0.0000	0.0000

Note: Values in parentheses show *t*-statistics. The statistics significant at 5 percent level of significance are indicated by*.
AR (1) = Autoregressive of order one model,
MA (1) = Moving Average model of order one.
We have used ARMA (1, 1) model for correcting our estimates for autocorrelation.

integration holds between Lahore and Hyderabad markets. While the values of ρ_2 are 0.68 in the regression for Peshawar on Lahore and 0.77 for Quetta on Lahore respectively. These regression results also show moderate to high spatial market integration.

In order to verify the long-run cointegration the order of integration of the residuals has been checked. If the estimated regression's residuals are integrated of order zero i.e. *I* (0), then there exists a long-run relationship between the wholesale prices of maize in Lahore and in each regional market. The estimated results show that the linear combination of the three price series gives the residuals, which are stationary at level that is they are integrated of order zero (Table 3). This validates our proposition that prices in Lahore market and in each regional market are indeed cointegrated.

Table 3

Augmented Dickey-Fuller Tests on the Level of Residuals

Estimated Residuals	Level	Mackinnon Critical Values for Rejection of Hypothesis of a Unit Root 1 %	5 %	10 %	Decision	Order of Integration
ln(HYD)	–11.59	–2.583	–1.943	–1.62	Stationary at level	*I* (0)
ln(PESH)	–7.81	–2.583	–1.943	–1.62	Stationary at level	*I* (0)
ln(QTA)	–4.74	–2.583	–1.943	–1.62	Stationary at level	*I* (0)

For checking stability between Lahore maize market price and each regional maize market price we estimate Error-Correction Model. The results are presented in Table 4. The results indicate that maize price in Lahore has an effect on the prices in the three regional maize markets. In all cases the adjustment parameter (π) appears with negative value and lies between 0.47 and 1. For Hyderabad, the adjustment of prices in this market due to changes in price in Lahore is quite high. In this market, the instantaneous adjustment in the same month is about 77 percent. For Quetta and Peshawar, the adjustment of prices due to changes in price in Lahore is only partial each month. It takes almost 2 months for prices to get adjusted due to a particular change in price in Lahore. Thus, there is a stable long-run relationship between Lahore maize market price and each regional maize market price.

Table 4

Empirical Findings of the Error-Correction Model

Variables	Δln(HYD)	Δln(PESH)	Δln(QTA)
Constant	0.002	0.003	0.006
	(0.374)	(0.520)	(1.069)
Δln(LHR)	0.384	0.211	0.309
	(4.014)*	(1.372)	(3.057)*
π	–0.777	–0.480	–0.578
	(–5.978)*	(–2.170)*	(–3.145)*
AR(1)			0.327
			(2.958)*
MA(1)	0.659	0.240	
	(4.982)*	(2.683)*	
R^2	0.514	0.466	0.4161
$\overline{R}^2$	0.507	0.454	0.4069
DW	2.001	1.989	2.0447
F-Stat	43.524	41.847	45.251
Prob (F-Stat)	0.0000	0.0000	0.0000

Note: Values in parentheses show *t*-statistics. The statistics significant at 5 percent level of significance are indicated by *.

Finally, to examine the causal relationship between the variables we have applied the Granger-causality test using lag length up to three periods. The results are listed in Table 5. The results show that the price in Lahore market Granger-causes the price in Hyderabad, Peshawar and Quetta. This uni-directional causality implies that Lahore dominates price formation with these regional markets. These results are in accordance with our expectations. Since Hyderabad and Quetta markets are in Sindh and Balochistan provinces and the production of maize is almost nil in these provinces. Therefore, they are net importer of maize from Punjab. Lahore is the main maize market in Punjab and price change in Lahore market affects price formation in Hyderabad and Quetta markets. Peshawar is the main market in North West Frontier Province (NWFP) of Pakistan. Although the contribution of this province in total maize production of the country is quite significant (45 percent) yet maize is cultivated basically for human consumption because it is also a big maize consuming region. While leaving only a small quantity to sale in the market for industry. In such circumstances, Lahore market is a big source of maize supply for non-consumption purposes to this market. Therefore, Lahore maize price influences the price patterns even in Peshawar market.

Table 5

Price Causality Results

Lagged Periods	Null Hypothesis	Decision
1	No Causality from HYD to LHR	Accepted
	No Causality from LHR to HYD	Rejected
2	No Causality from PESH to LHR	Accepted
	No Causality from LHR to PESH	Rejected
3	No Causality from QTA to LHR	Accepted
	No Causality from LHR to QTA	Rejected

5. CONCLUSION

After wheat and rice, maize is the third most important cereal crop in Pakistan. Maize occupies around 5 percent of the total cropped area and 8 percent of the total area under food crops. Maize is mainly cultivated in Punjab and NWFP. As presently most of the market surplus is generated in Punjab, therefore, it is mostly traded from Punjab to the other three provinces.

Following Ravallion (1986), we assume a radial market structure where there is a group of local, regional markets and a central market in Lahore, that is not only the capital city of Punjab but also is a major centre for business and trade. The regional markets chosen are those in Hyderabad, Quetta and Peshawar. These regional markets are located in maize deficit provinces like Sindh and Balochistan and big maize producing and consuming North West Frontier Province respectively. Trade between regional markets may exist but trade with the central market dominates price formation and accordingly we assume three pair-wise price relationships i.e. between the price in Lahore and those in the regional markets.

First of all, we have tested price integration to check the relationship between wholesale price of maize at Lahore and each of three regional markets. Price integration analysis shows a stable long-run relationship between the Lahore price and each of regional price. Thus, maize markets across Pakistan are efficient and are functioning well. The high degree of market integration observed in this case is consistent with the view that Pakistan's maize markets are quite competitive and provide little justification for extensive and costly government intervention designed to improve competitiveness to enhance market efficiency. Further, in its relationship with Hyderabad, Peshawar and Quetta, Lahore is dominant and leader in price formation. It actually provides an opportunity to the government to stabilise prices in Lahore market and rely on arbitrage to produce similar outcomes in other markets. This reduces the cost of stabilisation considerably.

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