Pakistan J. Agric. Res. Vol. 28 No. 4, 2015

SPATIAL PRICE TRANSMISSION IN PAKISTAN: THE CASE OF WHEAT AND RICE MARKETS

Umar Ijaz Ahmed*, Liu Ying**, Muhammad Khalid Bashir***, Muhammad Amjed Iqbal*, Muhammad Rizwan*, Muhammad Mazhar Iqbal****, Muhammad Rafi Qamar***** and Aftab Nazeer******

ABSTRACT:- This study investigates the spatial price transmission among major wheat and rice markets of Pakistan using their monthly retail prices. For analysis Vector Error Correction Model and Co-integration approach were employed. Results showed that wheat and rice market prices are integrated. Some markets have positive or negative transmission shocks on each other due to the different geographical locations and transport infrastructure. All the wheat markets are adjusted to price changes in the long run equilibrium except few markets. Unidirectional and bidirectional causality exists between wheat and rice markets. Bad and poor infrastructure is a major impediment to price transmission among the markets. These market imperfections lead to food insecurity in the country. Government should formulate better policies and develop infrastructure towards better and efficient market function. The results of this study will help the policy makers to formulate a better policy to enhance marketing function to overcome food insecurity situation.

Key Words: Wheat; Rice; Market Integration; Price Transmission; Vector Error Correction Model; Causality; Pakistan.

INTRODUCTION

Agriculture is the most important sector of Pakistan economy with a growth rate of 2.1% during 2013-14. The purpose of this study is to make sure the sufficient food availability and its accessibility to the population to overwhelm food insecurity and unemployment (GoP, 2014). Cereal crops are the major part of the diet of the people of Pakistan. Cereals account for 47% to per capita total calorie supply and 46% to per capita protein supply (Nazli et al., 2012). In cereals, wheat and rice are two major crops in Pakistan. Wheat is grown on 0.9 mha which is 4.4% higher than the last year's area. In 2013-14, the production of wheat in the country was 4.3% higher than last year which was 25.3 mt (Figure 1). The contribution of wheat in the value addition of agriculture is 10.3% and 2.0% share in GDP. The drivers of increased production are increased cultivated area, better farm practices and favorable weather conditions suitable

* *Department of Agricultural Economics, University College of Agriculture, University of Sargodha, Sargodha, Pakistan.*
** *College of Economics and Management, Huazhong Agricultural University, Wuhan 430070, Hubei Province, P.R. China.*
*** *Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad, Pakistan.*
**** *Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan.*
***** *Department of Agronomy, University College of Agriculture, University of Sargodha, Sargodha, Pakistan.*
****** *Department of Agricultural Engineering, Bahauddin Zakariya University, Multan, Pakistan.*
Corresponding author: liuyhzau@gmail.com

for healthy grain. In Pakistan market forces didn't work perfectly for price determination because Government announce procurement price and buy wheat directly from farmers (GoP, 2014).

After wheat, rice is second vital staple food and key cash crop. The contribution of rice in GDP is 0.7% and its value addition in agriculture is 3.1%. About 20.8% increment of area under rice has been recorded in 2013-14 and now the area under cultivation of rice is 0.28 mha (Figure 1). Rice production also showing an increase of about 18.5% in 2013-14 and earns a healthy foreign exchange for the country. The higher productivity is due to area under cultivation but the required yield was not obtained due to natural calamities and crop diseases (GoP, 2014).

According to economic theory, it is essential that markets and marketing channels should be functioned properly for the optimum resource allocation (Abdulai, 2000). In many countries, price transmission and market integration are common indicators and tools to measure performance of markets. Spatial market integration defined as long run relationship among prices or their co-movement that leads to smooth price transmission signals and information across spatial integrated markets (Ghafoor et al., 2009). Prices are determined simultaneously in various locations and prices are transmitted from one market to other market (Gonzalez and Helfand, 2001). According to Sexton et al. (1991) spatial price behavior is a key indicator of an overall market performance. For efficient allocation of resources and price determination, a well-integrated market system is necessary. This also leads to rapid growth in agriculture sector due to investment in new technology (Kurosaki, 1996; Ahmad, 2003).

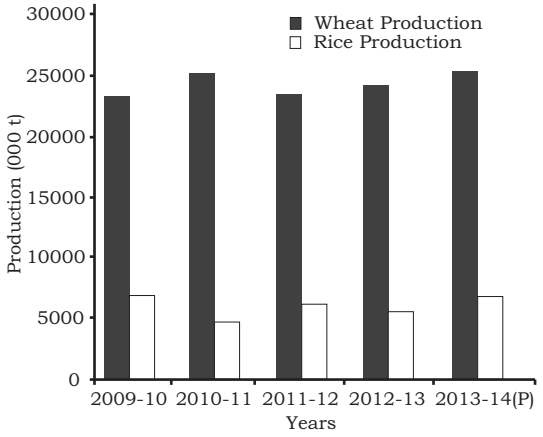

Figure 1. Wheat and rice production in Pakistan

As wheat and rice are the major staple grain crops, Pakistan's population gets 40-45% nourishment from grains and from rich families to poor families these are the essential part of meal. To achieve food security, the production and marketing mechanism of wheat and rice markets should be better. So, this study pursues to analyze price transmission and spatial market integration in selected wheat and rice markets. The objectives are to scrutinize the order of integration of the monthly retail prices, determine the degree of co-integration between the market prices, analyze the price transmission using vector correction model and determine the causality association between the markets.

MATERIALS AND METHOD

Wheat and rice are the main staple food crops in Pakistan. The time series data from January 2006 to June 2014 were downloaded from

Global Information and Early Warning System database of Food and Agriculture Organization (FAO-GIEWS, 2014) website. Five central markets namely Karachi, Lahore, Multan, Peshawar and Quetta were used in the analysis with known distances from each other (Table 1). Spatial price transmission investigation in major wheat and rice markets of the country was done by employing Vector Error Correction Model (VECM) and Co-integration approaches. These techniques were used by several studies like Minot (2011); Hossain and Verbeke (2010); Ghafoor et al. (2009); Zahid et al. (2007) and Lohano et al. (2005).

Table 1. Distance between different markets (km)

Cities	Karachi	Lahore	Multan	Peshawar	Quetta
Karachi	-	1283	938	1450	732
Lahore	1283	-	344	512	930
Multan	938	344	-	584	586
Peshawar	1450	512	584	-	840
Quetta	732	930	586	840	-

Source: http://www.travelmath.com/drive-distance/

To conduct the test of co-integration, test for the presence of unit root or non-stationary in the data was made. For the validation of co-integration test, the time series data should be of same order of integration. Augmented Dickey Fuller unit root tests were employed (Dickey and Fuller, 1981) (Table 2). The ADF regression is calculated using the x_i series as follows:

$$\Delta x_i = a + (\delta - 1)x_{i-1} + \sum_{k=1}^{i} \varphi k\, x_{i-k} + \mu_i$$

where,

Δ = Difference sign

l = Autoregressive lag length

a and φ = Coefficients of interest

Co-integration test helps to determine whether the price series have long run relationship or can diverge in the short run while in long run prices move together. Optimum order of lag length was specified before employing co-integration tests. To determine the optimum lag length the Akaike information criteria (AIC)

Table 2. Augmented Dickey Fuller test results (Intercept & no trend)

Markets	At level			At 1st difference		
	t-stat	Prob.	Critical value at 1% level	t-stat	Prob.	Critical value at 1% level
Wheat Price Series						
Karachi	-1.267	0.642	-3.498	-7.466	0.000	-3.498
Lahore	-1.187	0.678	-3.497	-7.011	0.000	-3.497
Multan	-1.104	0.712	-3.496	-8.407	0.000	-3.497
Peshawar	-1.217	0.665	-3.496	-8.041	0.000	-3.497
Rice Price Series						
Karachi	-0.838	0.804	-3.498	-6.952	0.000	-3.498
Lahore	-0.935	0.773	-3.497	-7.352	0.000	-3.497
Multan	-1.016	0.745	-3.497	-6.874	0.000	-3.497
Peshawar	-1.001	0.751	-3.496	-7.866	0.000	-3.497
Quetta	-0.965	0.763	-3.497	-6.832	0.000	-3.497

and Schwartz Information (SIC) were employed. Co-integration test was employed using the most popular co-integration test method given by Johansen and Juselius (1990). The test used two kinds of log-likelihood ratios to define the number of co-integrating vectors (r) in the Vector Error Correction Model (VECM): the maximum eigen value and trace statistics. In the first test the r = 0 (null hypothesis) for non co-integrating relationship, upon rejection subsequent null hypothesis (H_0: r = 1, H_0: r = 2, etc.) are verified until a null can no longer be rejected. The ratio statistics for the trace test and maximum Eigen value test can be defined with the help of following equations:

Trace Statistic

$$(\lambda\text{-trace}) = -N\sum_{j=r+1}^{1}\ln(1-\lambda_j)$$

The null of r co-integrating vector against the alternative of r +1 is tested by

Maximum Eigen Value Statistic

$$(\lambda\text{-max}) = -N\ln(1-\lambda_{r+j})$$

where,

r = Co-integrated number of pair-wise vector

λ_j = j^{th} Eigen value of matrix

N = Number of observations

λ = Trace is not an independent test, but a series of tests correspond to different r value

λ max tests each Eigen value separately.

To examine the short run dynamic and speed of adjustment, Vector Error Correction Models (VECM) for different price series were estimated. Engle and Granger (1987) identified that set of co-integrated variables generates a mechanism called "Error Correction Model", that confines the long-run behaviour of the endogenous variables to cong-regate their counter bracing connections, while letting a varied range of short-run dynamics (Arshad and Hameed, 2009). Hence, VECM is an extended multi-variate form of Error Correction Model (ECM) which is used to test the effect of variables on each other.

The general regression equation form for VECM is as follows:

$$\Delta x_i = \alpha\beta' x_{i-1} + \Gamma_1\Delta x_{i-1} + \ldots\ldots + \Gamma_{\delta-1}\Delta x_{i-\delta+1} + \mu_i$$

where,

x_i = N-dimensional vector of obvious variable

α and β = (N x r) matrices of rank r

More precisely,

β = Co-integration matrix

r = Co-integrating rank of the process

When the prices of two markets (P^{M1} and P^{M2}) of the same commodity are co-integrated, then the Vector Error Correction Model can be written as follows:

$$\Delta lnP_i^{M1} = a_0 + \varphi(P^{M1}_{j-1} - \beta P^{M2}_{j-1}) + \sum_{j=0}^{I}\partial_j\Delta P^{M2}_{j-1} + \sum_{j=0}^{I}a_j\Delta P^{M1}_{j-1} + \mu_i$$

where,

P^{M1} & P^{M2} = Prices of the two markets of the similar production

l = Lag length

Δ = First-difference sign

α = Short-run effects

β = Co-integrating parameter that describes the long run stability among the two prices.

As the prices are expressed in logarithms, the co-integration factor (β) is the long-run elasticity of the domestic price with respect to the local or global price. Thus, β is the

long-run elasticity of price transmission and the expected value is $0<\beta\leq1$, θ is the error correction coefficient and reflects the speed of adjustment. It is expected to fall in a range of $-1<\varphi<0$ and μi is the error term.

The final test examines the causality direction among different markets within a bivariate context. If two markets are co-integrated, the price in one market would normally be found to Granger-cause the price in the other market, and/or vice versa. Walt test and joint F-statistics were used to detect the direction of causality.

RESULTS AND DISCUSSION

Unit Root Test

To test the existence of unit root in price series, Augmented Dickey Fuller (1981) was used. The presence of unit root is rejected at 1% level of significance for all price series after their first difference (Table 2). This provides evidence that all variables are stationary and integrated of the same order I(1), thus proceed for the co-integration test to determine if there exists a long-run relationship between different market prices. The results are in accordance with Zahid et al. (2007) and Ghafoor et al. (2009).

Co-integration Test

The co-integration considers phenomena of variables in the long run only. Johansen and Juselius (1990) test was used to assess the existence of co-integration that the price series have long run relationship. The results elucidate that the optimal lag numbers are 1 and 2 for wheat and rice price series, respectively determine by the Akaike Information Criterion (AIC) and Schwartz Information Criterion (SIC). Similarly two co-integrating vectors were found for both price series (Table 3). Trace statistics of first and second value for wheat and rice price series are significant at 10% level of significant. Mushtaq et al. (2006); Ghafoor et al. (2009) and Ghafoor and Aslam (2012) also found overall integration in grain markets of Pakistan.

Vector Error Correction Model

The co-integration tests showed that the market price series of the two commodities are co-integrated; then the short-run effects or price transmission between different markets is estimated (Table 4 and 5).

For wheat markets, Karachi

Table 3. Johansen Co-integration Test results

Commodity	Lag 1 length	Hypothesized No of CE(s)	Trace Test Statistics	Eigen Value	Critical Value (5%)	Prob.	Rank (r)
Wheat	1	r=0	59.57614*	0.217087	47.85613	0.0027	r=2
		r≤1	35.10276*	0.214301	29.79707	0.0111	
		r≤2	10.98459	0.070336	15.49471	0.2124	
		r≤3	03.691404	0.036241	3.841466	0.0547	
Rice	2	r=0	86.84513*	0.323138	69.81889	0.0012	r=2
		r≤1	48.20656*	0.233483	47.85613	0.0463	
		r≤2	21.88257	0.104819	29.79707	0.3051	
		r≤3	10.92034	0.072338	15.49471	0.2164	
		r≤4	03.486619	0.034605	3.841466	0.0619	

** = Significance at 10%*

Table 4. Vector Error Correction model results for wheat

Independent variables	Dependent variables			
	ΔlnWPK	ΔlnWPL	ΔlnWPM	ΔlnWPP
$\Delta lnWPK_{t-1}$		-0.244625*	-0.280098	-0.218592
$\Delta lnWPL_{t-1}$	0.138280		0.281158	0.097230
$\Delta lnWPM_{t-1}$	0.002332	0.144930		0.085207
$\Delta lnWPP_{t-1}$	0.297401**	0.054091	0.160231	
ECT_1	0.082394	0.339853***	0.522724***	0.479144***
ECT_2	0.106070	0.428519**	0.086408	0.029279
Constant	0.006979	0.008243*	0.008776*	0.007172
R-squared	0.207335	0.276021	0.178127	0.144045
F-statistic	4.054297	5.909470	3.359354	2.608419

*Δ = First difference, ***, **and * -Significance at 1%, 5% and 10%, respectively*

showed a significant effect at 10% level on Lahore wheat market price and induces a transmission of -24.4% within one month lag period. Similarly, Peshawar wheat market price revealed a significant positive transmission of about 30% to Karachi wheat price. The error correction term (an error correction term lagged one period) represent the price deviation from the

Table 5. Vector Error Correction model results for rice

Independent variables	Dependent variables				
	lnRPK	lnRPL	lnRPM	lnRPP	lnRPQ
$\Delta lnRPK_{t-1}$	-	-0.251329	0.081002	-0.164424	-0.242685
$\Delta lnRPK_{t-2}$	-	-0.081648	0.061171	0.066005	-0.123382
$\Delta lnRPL_{t-1}$	-0.112636	-	-0.168401	-0.183022	-0.100776
$\Delta lnRPL_{t-2}$	0.108962	-	0.114981	0.127132	0.171494
$\Delta lnRPM_{t-1}$	-0.142821	-0.011374	-	0.192591	0.121840
$\Delta lnRPM_{t-2}$	-0.146789	-0.089727	-	-0.012672	0.019198
$\Delta lnRPP_{t-1}$	0.459465***	0.601407***	0.289012*	-	0.404369**
$\Delta lnRPP_{t-2}$	0.233571	0.217798	-0.079728	-	0.025566
$\Delta lnRPQ_{t-1}$	0.011875	0.104702	-0.062375	-0.107518	-
$\Delta lnRPQ_{t-2}$	0.171581*	0.214385*	0.165202	0.246381**	-
ECT_1	-0.337620***	0.157686	-0.199102*	-0.239484*	0.285782**
ECT_2	-0.106784	-0.550610***	0.082908	-0.021130	-0.377900***
Constant	0.002673	0.002241	0.006235	0.005997	0.005523
R-squared	0.542828	0.504292	0.262196	0.300995	0.297914
F-statistic	8.509423	7.290783	2.546839	3.085997	3.041014

*Δ = First difference, ***, ** and * =Significance at 1%, 5% and 10% , respectively.*

estimated long-run co-integrating relationship. The error correction terms for Lahore, Multan and Peshawar adjust or response to price deviations or perturbations from long-run equilibrium around 34%, 52% and 48%, respectively within a month. But Karachi market price of wheat did not adjust to change in these markets within the same period. This is due to poor road infrastructure and different geographical locations. In conclusion for wheat markets about 30-52% disequilibrium has been removed within one month. These results are similar to Acquah and Owusu (2012) which showed that most of the disequilibrium was corrected within two weeks.

Peshawar showed a significant short-run price transmission in all the four markets and the rates are 46%, 60%, 29% and 40% to Karachi, Lahore, Multan and Quetta, respectively. Similarly, Quetta rice market induces 21% and 25% price transmission to Lahore and Peshawar, respectively, within a lag of one to two months. The negative signs and significant levels of the error correction terms are within expectation. This implies that all these markets adjust to prices changes toward long-run equilibrium. Lahore rice market prices adjust faster (55%) than others, followed by Quetta (38%), Karachi (34%) and Multan (20%). This is because of high production and consumption of rice in upper Punjab, better road infrastructure and facilities in the markets. About 29-60% disequilibrium is corrected within the lag of one to two months. Ghafoor and Aslam (2012) also found one month lag period for the adjustment of disequilibrium in rice markets.

Causality Test

The Granger causality tests indicate the existence at least unidirectional causality linkages between prices of different markets. The results where causality relationship between variables using Wald test and its joint F-statistics was done (Table 6). For wheat markets, unidirectional causality running from Peshawar to Karachi to Lahore was found. For rice markets, the results revealed unidirectional causality linkage running from Peshawar to Karachi and Lahore and from Quetta to Lahore. Bidirectional causality relation between Peshawar and Quetta was also found. The results are similar to Ge et al. (2010). From the causality analysis it is concluded that Peshawar wheat and rice market prices have influence on the other domestic market prices. Price shocks in Peshawar grain markets should be an alert for other regions and proper policy should be taken to curve price distortion.

Table 6. Causality Test results

Null hypothesis	Wald tests		
	Statistics	Probability	Decision
Wheat			
Karachi causes Lahore	2.783911*	0.9860	Accepted
Peshawar causes Karachi	6.339214*	0.0135	Accepted
Rice			
Peshawar causes Karachi	4.592372**	0.0127	Accepted
Peshawar cause Lahore	6.118066***	0.0033	Accepted
Quetta causes Lahore	2.662812*	0.0755	Accepted
Peshawar causes Quetta	2.727218*	0.0711	Accepted
Quetta causes Peshawar	2.585977*	0.0812	Accepted

****, ** and * = Significance at 1%, 5% and 10%,respectively*

CONCLUSION

Regarding causality test, the wheat markets, unidirectional causality is running from Peshawar to Karachi to Lahore. For rice markets, unidirectional linkages is running from Peshawar to Karachi and Lahore and

from Quetta to Lahore. It is concluded that long distances between markets, different geographical locations and poor road and transport infrastructure cause slow price transmission among market prices. This study also elucidated the condition of other commodity markets and industries. This necessitates further research to identify the exterior and interior aspects such as market structure, government strategy and self-sufficient production, product features and utilization concerning market integration. Government should take steps towards policies that enhance market efficiency so that the issues related high food prices and food insecurity can be handled.

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AUTHORSHIP AND CONTRIBUTION DECLARATION

S. No	Author Name	Contribution to the paper
1.	Dr. Umar Ijaz Ahmed	Conceived the idea and do all the things about article
2.	Dr. Liu Ying	Technical input at every step
3.	Dr. Muhammad Khalid Bashir	Technical input at every step especially in methodology, Results and discussion
4.	Mr. Muhammad Amjed Iqbal	Data analysis
5.	Mr. Muhammad Rizwan	Data analysis
6.	Dr. Muhammad Mazhar Iqbal	Introduction and references
7.	Dr. Muhammad Rafi Qamar	Results and discussion, references
8.	Mr. Aftab Nazeer	Discussion and references

(Received January 2015 and Accepted July 2015)