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GLOBAL TO DOMESTIC PRICE TRANSMISSION BETWEEN THE SEGMENTED CEREALS MARKETS: A STUDY OF AFGHAN RICE MARKETS

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Abstract

This paper examines cointegration and the difference in the extent of price transmission, and speed of adjustment between global and domestic prices of high and low quality rice. Unit root tests, cointegration tests and error correction models are employed in the analysis. While there are no comparable studies in the literature, the findings of this study indicate that the dynamics of price transmission may be different between high and low quality rice markets. That is, the extent of price transmission appears to be larger for the global prices of low quality rice whereas the speed of adjustment to the long-run equilibrium may be faster for domestic prices of high quality rice. Moreover, a shock in the global prices of low quality rice may have a long-lasting effect on domestic prices of low quality rice as compared to their high quality counterparts affecting domestic prices of high quality rice.
Key Words: *Price transmission; cointegration; segmented rice markets; Afghanistan*

1. Introduction

Spikes in global food prices, especially staple foods, have been a crucial topic of policy discussions. Given the increasing interdependence among countries in today's globalizing world, shocks in global food prices affect domestic food prices more than any other times. The enormous increases in global food prices of 2007-2008 were transmitted in varying magnitudes to domestic markets (Conforti, 2004; Ghoshray, 2011; Greb, Jamora, Mengel, von Cramon-Taubadel, & Nadine, 2012; Minot, 2011). These transmissions brought about a welfare loss to the poor households in developing countries (FAO, 2008; Hoyos & Medvedev, 2009). Afghanistan being a net food importer with a low government capacity to respond to high food prices and the prevalence of food insecurity and poverty, it is considered a vulnerable country to shocks in global food prices (World Bank, 2013).

Rice (paddy) accounted for about 7% of the total area planted to cereals during 2013/14 and it is mainly grown in the northern and eastern provinces of Afghanistan. Rice is the second major staple food in the country that constitutes approximately 7% of the daily calorie intake with an average per capita consumption of 17 kilograms per year[i]. Domestic supply of rice is relatively more volatile than its consumption, as reflected in a coefficient of variation of 24% and 13%, respectively. Due to a prolonged deficit in rice production, the country strongly depends on rice imports for meeting the increasing demand of domestic markets. Rice imports in-flow to the country has started during the early 1990s and reached to its historically high level (272,000 tonnes) in 2001/02. Pakistan is the major supplier of rice to Afghanistan that accounted for 92% (42,227 tonnes) of total high quality (46,089 tonnes) and 99% (63,934 tonnes) of total low quality (64,482 tonnes) rice imports during 2014/15 (Central Statistics Organization, 2014). This indicates that Pakistani rice markets may have a greater influence on domestic rice markets and that changes in Pakistani rice prices may largely be transmitted to domestic rice markets in the country.

The transmission of cereals prices from global to domestic markets is studied extensively after the dramatic spikes in global food prices of 2007-2008 (e.g., Conforti, 2004; Ghoshray, 2011; Greb *et al.,* 2012; Minot, 2011), but no such study is conducted for rice markets in Afghanistan. Rice is a differentiated product and rice market is highly segmented (Agcaoili-Sombilla & Rosengrant, 1994; Jamora & von Cramon-Taubadel, 2012; Rakotoarisoa, 2006). However, previous studies on price transmission from global to domestic markets ignored considering rice as a differentiated product and used aggregates of global and domestic rice prices in the analysis.

Since the milled rice has different quality clusters in terms of its composition and length of kernels, changes in global prices of its various grades may not be uniformly transmitted to domestic markets with different speeds of adjustment and consequences for the poor[ii]. But, the difference in the extent of price transmission and speed of adjustment between different grades of rice did not receive due attention in empirical studies on price transmission from global to domestic markets. Furthermore, while the effect of a structural break on unit root and cointegration tests is well known (Johansen, Mosconi, & Nielsen, 2000; Perron, 1989), it is frequently overlooked in the earlier research works. With this background in mind, the present study explores the temporal changes in domestic and global prices of high and low quality rice and examines the long-run relationship as well as the difference in the magnitude of price transmission and speed of adjustment between global and domestic prices of high and low quality rice.

1.1. Trends in Global and Domestic Prices of High and Low Quality Rice

The high quality rice prices experienced a dramatic increase in global and domestic markets between January 2007 and June 2008 when Thai 100% B, Pakistani basmati and domestic prices of high quality rice swung up (in real terms) by 176%, 57% and 85%, respectively. Figure 1 depicts the pattern of changes in domestic and global prices of high quality rice from January 2007 to March 2015. The Figure shows that domestic prices of high quality rice follow the global reference prices of high quality rice with varying degree of price volatility, i.e., 24%, 19% and 9% for Thai 100% B, Pakistani basmati, and domestic rice (Sela) prices, respectively. It is evident from the Figure that domestic prices of high quality rice are quite above the Thai 100% B, but very close to Pakistani basmati rice prices with an average price of US$ 1160, US$ 1020 and US$ 517 per tonne, respectively. This could be due to the stronger influence of Pakistan on domestic rice markets as a major rice exporter to Afghanistan.

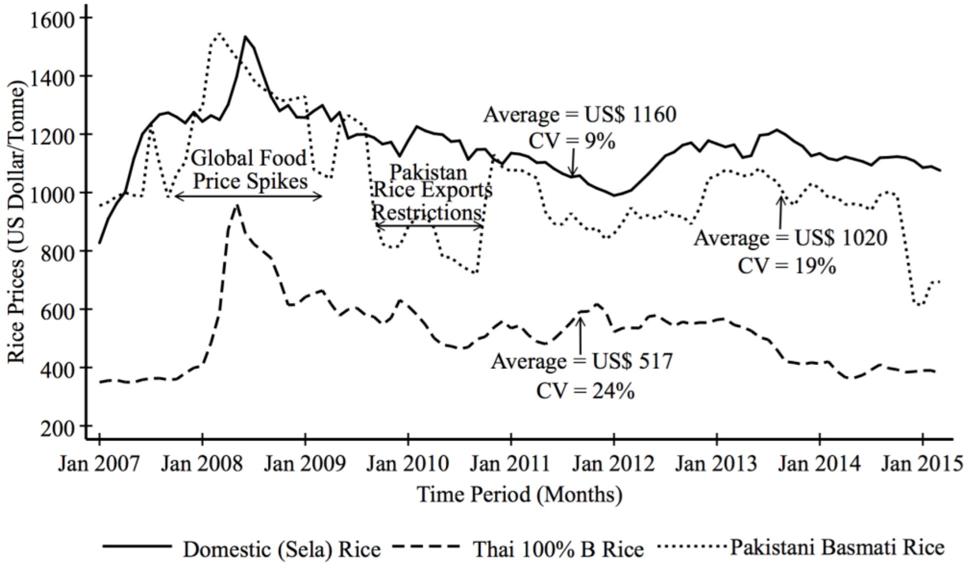

Figure 1. Pattern of Changes in Global and Domestic (Real) Prices of High Quality Rice

The low quality global and domestic rice prices also underwent an enormous increase between January 2007 and June 2008 reflected in a rise (in real terms) of 180%, 153% and 66% in Thai 25% broken, Pakistani 25% broken and domestic prices of low quality rice, respectively. Trends in global and domestic prices of low quality rice are portrayed in Figure 2. It can be observed that domestic prices of low quality rice (Permal) follow the global reference prices of low quality rice with some short-run divergence from each other. The price volatility is higher for Pakistani 25% broken (35%) followed by Thai 25% broken (23%) and domestic (12%) prices of low quality rice. It can be said that the price volatility is relatively higher in global and domestic prices of low quality rice as compared to those of high quality rice. The comparatively low level of volatility in domestic prices of high and low quality rice maybe due to the fact that rice imports play an important role in stabilizing domestic cereals markets (Persaud, 2010). That is, in the absence of trade restrictions by the major supplier of rice to Afghanistan, i.e., Pakistan, rice imports may reduce variability in domestic rice markets. This is reflected in the higher variability of rice production (24%) as compared to its consumption (13%) in the country.

The domestic prices of low quality rice are well above its global reference prices, i.e., Pakistani and Thai 25% broken rice prices, with an average price of US$ 629, US$ 385 and US$ 457 per tonne, respectively. Factors such as the transaction costs, depreciation of US dollar against Baht coupled with depreciation of Afghani and Pakistani Rupees against US dollar maybe responsible for the higher levels of domestic prices of high and low quality rice. It is observable from Figure 1 and Figure 2 that the changing patterns of Thai and Afghan prices of high and low quality rice resemble more as compared to those of Pakistani prices of high and low quality rice. This may be due to the highly regulated nature of rice production and marketing in Pakistan.

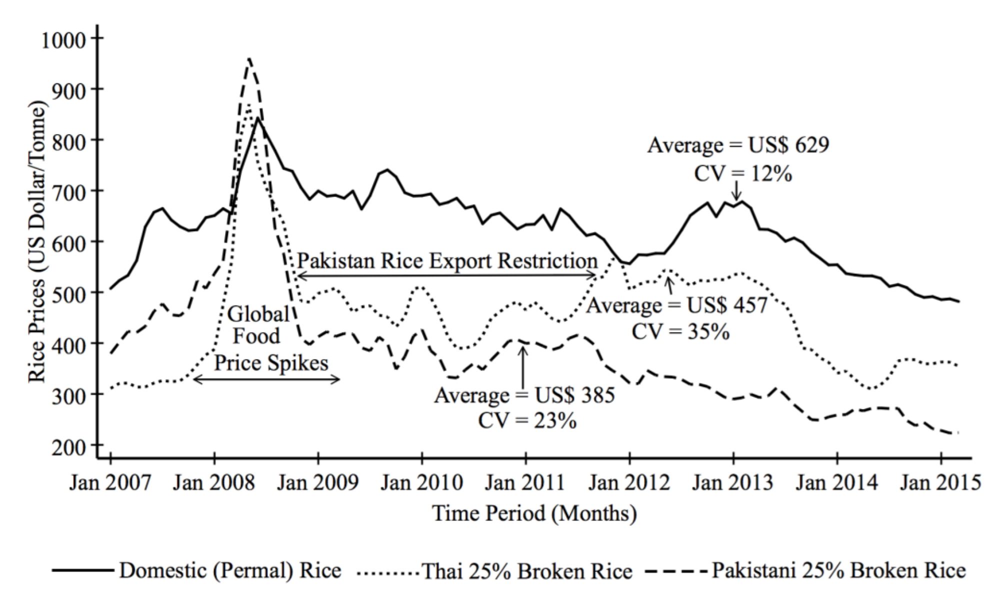

Figure 2. Pattern of Changes in Global and Domestic (Real) Prices of Low Quality Rice

2. Data and Methods

2.1. Data Used in Analysis

To achieve the objectives of this study, monthly time series data on global and domestic rice prices, consumer price indices (CPIs) and exchange rates coupled with annual data on rice production, consumption and imports are collected and analyzed. The data are obtained from sources such as Food and Agriculture Organization, International Monetary Fund, World Food Program and International Rice Research Institute for a period from January 2007 to March 2015 (Table 1). All the price series are converted to real US dollar using CPIs of the corresponding country. Logarithmic form of the price series is used throughout the analysis.

The rice export market is segmented and there is no a single rice grade that can best represent the global (world) rice prices (Jamora & von Cramon-Taubadel, 2012). Therefore, milled rice is divided into high and low quality clusters on the basis of the length and composition of rice kernels in the present study. Thai 100% B and Pakistani Basmati rice export prices (free on board) are taken as global reference prices for high quality rice while Thai and Pakistani 25% broken rice export prices (free on board) are considered as global reference prices for low quality rice[iii]. The average retail prices of Sela and Permal rice in the 7 central provincial markets of Afghanistan, namely, Kabul, Jalalabad, Kandahar, Hirat, Mazar, Faizabad and Maimana, are considered as domestic reference prices for high and low quality rice, respectively.

Table 1. Description of Data Series Used in This Study

Sr. No.	Data Series	Description	Source
1	Sela rice prices (retail)	Domestic rice prices collected from 7 provincial central markets	*Market Price Bulletins*, Vulnerability Analysis and Mapping Project, World Food Program, Afghanistan Office
2	Permal rice prices (retail)		
3	Thai 100% B (f.o.b.)	Thai rice export prices (free on board) in Bangkok	Food Prices Monitoring and Analysis Tool, Food and Agriculture Organization (FAO) *Web: http://www.fao.org/giews/pricetool/* *Accessed: May 6, 2015*
4	Thai 25% Broken (f.o.b.)		
5	Pakistani Basmati (f.o.b.)	Pakistani rice export prices (free on board)	
6	Pakistani 25% Broken (f.o.b.)		
7	Consumer Price Indices (CPIs)	National CPIs (all items) of Afghanistan, Pakistan and Thailand	International Financial Statistics, International Monetary Fund *Web: http://data.imf.org* *Accessed: May 6, 2015*
8	Exchange Rates (ERs)	Dollar value of Afghani, Pakistani Rupees and Thai Baht	
9	Miscellaneous	Annual data on rice production, consumption and import	FAOSTAT Online Database, FAO; World Rice Statistics Online Query Facility, IRRI *Web: http://faostat3.fao.org* *Web:http://ricestat.irri.org:8080/wrs2/entrypoint.htm* *Accessed: May 23, 2015*

2.2. Methods of Analysis

Augmented Dickey and Fuller (1979), and Phillips and Perron (1988) unit root tests were employed to examine the non-stationarity property and order of integration of the price series. Perron (1989) showed that the standard unit root tests are biased towards non-rejection of a false unit root hypothesis in the presence of a structural break. Thus, Lee and Strazicich (2003) unit root test with a single structural break in level (Model A) as well as both in level and trend (Model C) was used to capture the effect of a possible structural break in testing for a unit root. Unlike other unit root tests with structural break, Lee and Strazicich (2003) unit root test allows for a structural break under the null and alternative hypothesis.

Cointegration between the pairs of global and domestic rice prices was analyzed in the absence and presence of a structural break using the maximum likelihood cointegration tests of Johansen (1988, 1996) and Johansen, Mosconi and Nielsen (2000), respectively. The latter test is a generalization of the former one and allows for up to two breaks in level at a known point in time. We considered a single endogenously identified break suggested by

Model A of Lee and Strazicich (2003) unit root test on level of the prices series. The Johansen (1988, 1996) and Johansen et al. (2000) maximum likelihood cointegration tests rely on the relationship between the rank of a matrix (π) and its characteristic roots ($\hat{\lambda}_i$). A zero rank denotes no cointegration and hence no long-run relationship between the variables, the pairs of prices in our case, otherwise there is one or more cointegrating equations between them. Equations 1 and 2 represent a general form of Johansen (1988, 1966) and Johansen *et al.* (2000) cointegration models with intercept restricted to the cointegrating vector, respectively.

$$\Delta P_t = \pi P_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \, \Delta P_{t-i} + \varepsilon_t \qquad (1)$$

where ΔP_t is a $(n \times 1)$ vector of I(1) price series, π is the cointegrating matrix, ε_t is a $(n \times 1)$ vector of white noise disturbance terms.

$$\Delta P_t = \pi P_{t-1} + \delta E_t + \sum_{i=1}^{p-1} \Gamma_i \, \Delta P_{t-i} + \sum_{i=1}^{p}\sum_{j=2}^{q} k_{j,i} \; D_{j,t-i} + \varepsilon_t \qquad (2)$$

where ΔP_t, π and ε_t are same as in Equation 1; p and q denote the lag order and the number of sample periods, respectively, E_t is a $(q \times 1)$ vector of dummy variables, i.e., $E_{j,t} = 1$ if observation t belongs to the jth period and 0 otherwise; $D_{j,t-i}$ is an impulse dummy, i.e., $D_{j,t-i} = 1$ if observation t is the ith observation of the jth period and 0 otherwise.

Johansen's trace test (Equation 3) was employed to estimate the number of cointegrating equations between global and domestic prices of high and low quality rice.

$$\lambda_{trace}\,(r) = -T \sum_{i=r+1}^{p} \ln\left(1 - \hat{\lambda}_i\right) \qquad (3)$$

The Granger representation theorem shows that an error correction model can best represent cointegrated series (Engle & Granger, 1987). As such, once cointegration between the pairs of global and domestic rice prices was established, separate vector error correction models were estimated for each pair of the global and domestic prices of high and low quality rice. Considering one-way price transmission, i.e., from global to domestic markets, the following standard vector error correction model (VECM), which is linear and symmetric in nature, was estimated using Johansen's maximum likelihood procedure:

$$\Delta P_t^d = \mu_0 + \alpha\left(P_{t-1}^d - \beta P_{t-1}^g\right) + \sum_{j,i=1}^{p-1} \delta_j \Delta P_{t-i}^d + \sum_{j,i=1}^{p-1} \theta_j \Delta P_{t-i}^g + \nu_t \qquad (4)$$

where ΔP_t^d stands for the first difference of logarithm of real domestic rice prices; P^d and P^g are logarithm of real domestic and global rice prices, respectively; μ_0, α, β, δ, θ are parameters of the model; $\alpha\left(P_{t-1}^d - \beta P_{t-1}^g\right)$ is the error correction term; and ν_t is the i.i.d. disturbance term.

It should be noted that as in unit root and cointegration analysis, an attempt was made to include a structural break in each of the VECMs by dividing the entire sample into two sub-samples, i.e., before and after the break, following Greb *et al.* (2012). Since most of the price series experienced a level shift at around mid-2008, as reported by Model A of Lee and Strazicich unit root test on level (Table 3), there were fewer observations in the first regime, i.e., before the break, which may have yielded unreliable results[iv]. Greb, von Cramon-Taubadel, Krivobokova, & Munk (2013) also reported the issue and danger of having only a small number of observations in one of the regimes. Hence, instead of dividing the entire sample into two regimes using the above-mentioned procedure, it was decided to use all the observations as one regime in estimating the VECMs. However, future studies may be expected to fill-up this gap employing alternative methods.

The orthogonalized impulse response function (OIRF) was used to trace the effects of a one standard deviation unit shock in global rice prices on that of domestic prices. Furthermore, the appropriate lag order for all unit root tests, cointegration tests, and vector error correction models was selected using Akaike, Bayesian, and Hannan and Quinn information criteria on the basis of similar results for at least two of the criteria.

3. Empirical Results

3.1. Unit Root Tests and Order of Integration

Since most of the economic series including prices are characterized by unit root process, testing for non-stationarity has become a common practice in the empirical analysis. Although the price series may be non-stationary in level, their first difference is often stationary. As such, the non-stationarity property of time series is examined both in level and first difference of the price series using Augmented Dickey and Fuller (1979), Phillips and Perron (1988), and Lee and Strazicich (2003) unit root tests.

Augmented Dickey and Fuller (ADF), and Phillips and Perron (PP) unit root tests were estimated in level and first difference of the price series considering the deterministic term of only an intercept and both an intercept and a linear trend in the models. Akaike, Beyesian, and Hannan and Quinn information criteria were used to choose the appropriate lag order on the basis of similar results for at least two of the criteria. Table 2 presents the results of ADF and PP unit root tests in level and first difference for the global and domestic prices of high and low quality rice. The results show that both ADF and PP tests accepted the null hypothesis of unit root in level of the price series, except for domestic prices of high quality rice. Although domestic and Pakistani prices of low quality rice are considered stationary in level by ADF test with intercept and linear trend, it is not supported by the corresponding PP test. However, both ADF and PP tests confirmed that all the price series are stationary in their first difference. In short, the results of ADF and PP tests showed that the rice price series are non-stationary in level, except for domestic prices of high quality rice, but they are stationary in first difference. Indicating that the rice price series are integrated of the same order or I(1).

ADF and PP unit root tests confirmed that domestic prices of high quality rice are stationary in level while ADF test with both intercept and trend alone considered domestic and Pakistani prices of low quality rice to be stationary in level. This prompted the need for employing unit root test with a structural break, which may have been occurred due to the drastic increase in food prices of 2007-2008. Hence, Lee and Strazicich (2003) unit root test with a single break was used to examine whether a possible break in level (Model A) or both in level and trend (Model C) affected the unit root process in the price series. Unlike other tests of unit root with structural break, Lee and Strazicich unit root test endogenously determines the break points and allows for structural break under both null and alternative hypothesis.

Table 2. Results of ADF and PP Unit Root Tests for Global and Domestic Rice Prices

Price Series	Lag	Augmented Dickey-Fuller Test		Phillips-Perron Test	
		with Drift (*Intercept*)	with Drift and linear Trend	with Drift (Intercept)	with Drift and Linear Trend
		Unit Root Test on Level			
DPHQR	1	-2.917*	-3.982*	-3.722**	-4.974**
DPLQR	1	-1.619	-3.733*	-1.261	-3.364
TPHQR	2	-2.613	-2.946	-2.040	-2.358
TPLQR	2	-2.810	-2.958	-2.212	-2.359
PPHQR	2	-2.006	-2.846	-2.094	-2.851
PPLQR	2	-1.307	-3.598*	-1.012	-3.187
		Unit Root Test on First Difference			
DPHQR	0	-7.385**	-7.488**	-7.427**	-7.583**
DPLQR	0	-7.568**	7.891**	-7.652**	-8.001**
TPHQR	1	-5.639**	-5.780**	-5.721**	-5.845**
TPLQR	1	-5.390**	-5.445**	-5.532**	-5.622**
PPHQR	2	-6.317**	-6.383**	-7.585**	-7.632**
PPLQR	2	-4.811**	-4.836**	-5.670**	-5.701**
Critical Values	1%	-3.499	-4.056	-3.498	-4.054
	5%	-2.892	-3.457	-2.891	-3.456

Notes: ** and * indicate 1% and 5% level of significance. Since the critical values of ADF and PP unit root tests on level and first difference were identical at two decimals, a single set of critical values was considered for testing the null hypothesis of unit root in level and first difference. The lag length is selected using Akaike, Beyesian, and Hannan and Quinn information criteria. DPHQR: Domestic Prices of High Quality Rice (Sela); DPLQR: Domestic Prices of Low Quality Rice (Permal); TPHQR: Thai Prices of High Quality Rice (100% B); TPLQR: Thai Prices of Low Quality Rice (25% broken); PPHQR: Pakistani Prices of High Quality Rice (Basmati); PPLQR: Pakistani Prices of Low Quality Rice (25% broken)

Table 3 summarizes the results of Lee and Strazicich unit root test with a single structural break in intercept (Model A) and in both intercept and slope (Model C). It is evident from the Table that all the price series are non-stationary in level but stationary in their first difference when a structural break is considered in the price series. This indicates that domestic and global prices of high and low quality rice are difference-stationary and integrated of the same order or I(1). Interestingly, the results expose the low power of ADF and PP unit root tests in the presence of a structural break, as they accepted a false alternative hypothesis of stationarity in level of the price series while the true process was probably non-stationary (Table 2). Hence, it can be said that in the presence of a structural break the standard unit root tests may not be only biased towards non-rejection of a false null, as shown by Perron (1989), but also toward acceptance of an untrue alternative hypothesis. The test also confirmed the occurrence of a structural break in the price series, which may be induced by the drastic spikes in global food prices of 2007-2008.

Table 3. Results of Lee and Strazicich Unit Root Test with a Single Structural Break

Price Series	Lag	Model A (Break in Level)		Model C (Break in Level and Slope)	
		Test Statistic	Break Point	Test Statistic	Break Point
		Unit Root Test on Level			
DPHQR	1	-1.280	2007:11	-2.618	2007:12
DPLQR	1	-1.952	2008:03	-3.305	2008:02
TPHQR	2	-2.437	2008:06	-3.648	2008:02
TPLQR	2	-2.741	2008:06	-3.268	2008:10
PPHQR	2	-3.153	2009:08	-3.115	2009:11
PPLQR	2	-3.246	2008:08	-4.170	2008:10
		Unit Root Test on First Difference			
DPHQR	0	-6.005**	2007:12	-8.380**	2008:02
DPLQR	0	-8.329**	2011:12	-8.237**	2009:02
TPHQR	1	-6.181**	2008:10	-6.062**	2008:08
TPLQR	1	-5.772**	2008:02	-5.451*	2009:08
PPHQR	2	-6.437**	2008:06	-6.479**	2014:05
PPLQR	2	-5.595**	2008:07	-5.295**	2009:03
Critical Value	1%	-4.545		-5.823	
	5%	-3.842		-5.286	

Notes: Model A allows for a one time change in the intercept or level while Model C allows for a change in both level and trend or slope. ** and * denote 1% and 5% level of significance, respectively. The critical values are taken from Lee and Strazicich (2003). The lag length is selected using Akaike, Beyesian, and Hannan and Quinn information criteria. For the full form of the abbreviations of price series, refer to the notes of Table 2.

3.2. The Long-run Equilibrium Relationships

The term cointegration is used to denote a long-run equilibrium relationship between non-stationary variables, which are integrated of the same order and have a linear combination that is itself stationary (Engle & Granger, 1987). It was showed in the previous section that the global and domestic rice price series are integrated of the same order or I(1). This allows conducting cointegration tests between the pairs of global and domestic rice prices. Since Johansen's cointegration test is sensitive to lag length, the appropriate lag order was selected using Akaike, Beyesian, and Hannan and Quinn information criteria. The decision was made on the basis of a majority rule, i.e., at least two of them must report similar lag length. Two variants of Johansen's cointegration tests, i.e., with and without a level shift, are used to find out the effects of a structural break on the long-run equilibrium relationship between the pairs of price series. Furthermore, as the price series follow a non-linear trend (Figure 1 & 2), the constant term is restricted to the cointegrating vector.

Table 4 presents the results of Johansen (1988, 1996) cointegration test without a break in the intercept. It is evident from the Table that domestic prices of high quality rice have a single cointegrating relationship with Thai and Pakistani prices of high quality rice at the

10% and 1% level of significance, respectively. Indicating that a long-run equilibrium relationship exists between domestic and global, i.e., Thai and Pakistani, prices of high quality rice during the study period. However, no cointegrating vector exist between domestic and global prices of low quality rice, even at the 10% level of significance, implying the absence of a long-run equilibrium relationship between them.

Table 4. Results of Johansen's Cointegration Test without a Level Shift

Price Pairs	Lag	Null Hypothesis	Trace Statistic	Critical Value		
				10%	5%	1%
DPHQR – TPHQR	3	$r = 0$	20.0*	18.0	20.2	24.5
		$r \leq 1$	6.44	7.60	9.14	12.5
DPLQR – TPLQR	2	$r = 0$	12.5	18.0	20.2	24.5
		$r \leq 1$	1.70	7.60	9.14	12.5
DPHQR – PPHQR	2	$r = 0$	29.5***	18.0	20.2	24.5
		$r \leq 1$	4.17	7.60	9.14	12.5
DPLQR – PPLQR	2	$r = 0$	13.5	18.0	20.2	24.5
		$r \leq 1$	2.67	7.60	9.14	12.5

Notes: ***, ** and * show 1%, 5% and 10% level of significance, respectively. The lag length is selected using Akaike, Beyesian, and Hannan and Quinn information criteria. Intercept is restricted to the cointegrating vector. For the full form of the abbreviations of price series, refer to the notes of Table 2.

The lack of cointegration between low quality domestic and global rice prices may be, *inter alia*, due to a structural break in the prices series that may have occurred as a result of the recent spikes in global food prices. Lee and Strazicich (2003) unit root test confirmed the existence of a structural break in level (Model A) and both in level and trend (Model C) of the price series (Table 3). Hence, Johansen *et al.* (2000) cointegration test with a single level shift was estimated and the results are provided in Table 5. Since Johansen *et al.* (2000) test examines hypothesis corresponding to Model A, the break points reported by Model A of Lee and Strazicich (2003) unit root test for the level of global prices of high and low quality rice were assumed to be the location of structural break in the price series.

Table 5 shows that domestic prices of high quality rice have at least one cointegrating vector with Thai and Pakistani prices of high quality rice at the 5% and 1% significance level, respectively. Although two cointegrating equations are reported between domestic and Pakistani prices of high quality rice at the 5% level of significance, it is not valid since the number of cointegrating vectors will always be one less the number of variables, i.e., $r = n - 1$. Indicating that both tests of cointegration confirmed a long-run relationship between the pairs of high quality global and domestic rice prices. Furthermore, after allowing for a level shift in the price series, domestic prices of low quality rice have one cointegrating equation with Thai and Pakistani prices of low quality rice at the 10% level of significance. This implies that the structural break distorted the long-run relationship between global and domestic prices of low quality rice. In a nutshell, domestic prices of high and low quality rice may diverge from the long run-equilibrium with the global rice reference prices in the short-run, but they converge towards equilibrium in the long run as a result of arbitrage, substitution or both (Ghoshray, 2008).

Table 5. Results of Johansen's Cointegration Test with a Level Shift

Price Pairs	Lag	Null Hypothesis	Trace Statistic	Critical Value		
				10%	5%	1%
DPHQR – TPHQR (2008:06)	3	$r = 0$	29.0**	22.6	24.9	29.8
		$r \leq 1$	7.56	10.3	12.2	16.15
DPLQR – TPLQR (2008:06)	2	$r = 0$	22.7*	22.6	24.9	29.8
		$r \leq 1$	7.84	10.3	12.2	16.2
DPHQR – PPHQR (2009:08	2	$r = 0$	39.0***	22.8	24.9	29.3
		$r \leq 1$	13.5	10.8	12.8	16.6
DPLQR – PPLQR (2008:08)	2	$r = 0$	23.2*	22.8	25.0	29.8
		$r \leq 1$	9.24	10.4	12.3	16.3

Notes: ***, ** and * show 1%, 5% and 10% level of significance, respectively. The lag length is selected using Akaike, Beyesian, and Hannan and Quinn information criteria. Intercept is restricted to the cointegrating vector. The figures in brackets are the corresponding break dates. For the full form of the abbreviations of price series, refer to the notes of Table 2.

It is believed that the landlocked countries with a poor infrastructure, such as Afghanistan, are much less likely to be following the movements in global prices (Zorya, Townsend, & Delgado, 2012). This, however, does not hold for Afghan high and low quality rice markets, as they are in a long-run relationship with global markets of high and low quality rice. Furthermore, Sharma (2003) found that rice prices of a few Asian countries are cointegrated with global prices of high and low quality rice, i.e., Thai 100% B (5 out of 16 countries) and Thai A1 (4 out of 16 countries). This lack of cointegration between the Asian and global rice markets may be due to, *inter alia*, ignoring a possible structural break and using aggregates of domestic rice prices in the analysis. However, factors such as poor infrastructure, high transaction costs and trade-distorting policies also affect cointegration between markets.

3.3. The Speed of Adjustment and Short & Long-run Dynamics

Although a few studies considered domestic and global rice markets to be segmented (e.g., Ghoshray, 2008; Jamora & von Cramon-Taubadel, 2012), no study attempted comparing price transmission dynamics from global to domestic markets between high and low quality rice. Table 6 summarizes the results of vector error correction models for the pairs of global and domestic prices of high and low quality rice. The speed of adjustment and cointegrating coefficients are the key parameters in spatial price transmission. It can be observed from the Table that the magnitude of Thai and Pakistani high quality rice price transmission is 15% and 46% while that for low quality Thai and Pakistani rice prices is 93% and 52%, respectively[v]. This suggests that changes in the global prices of low quality rice are transmitted in a greater extent to domestic markets as compared to those of high quality rice and that the global prices of high and low quality rice are, however, not transmitted uniformly to domestic rice markets[vi]. Distance and volume of trade may explain part of this behavior. In the short-run, domestic prices of high quality rice respond to previous period changes in Thai prices of high quality rice at 2 lag periods while they are influenced by Thai and Pakistani prices of low quality rice at 1 lag period.

Table 6. Results of Vector Error Correction Models for High and Low Quality Rice Prices

Estimates	Parameters of the Vector Error Correction Model (VECM)					
	α	β	δ_1	δ_2	θ_1	θ_2
	VECM for Domestic and Thai Prices of High Quality Rice					
Coefficients	-0.088**	0.145	0.121	0.172*	0.072	0.165**
Standard Error	0.025	0.128	0.095	0.085	0.044	0.048
P-Value	0.000	0.257	0.203	0.042	0.104	0.001
Half-Life	7.525					
R^2 = 0.369; RMSE = 0.024; LL = 364.354; SBIC = -6.973; Lag = 3; Observations = 96						
	VECM for Domestic and Pakistani Prices of High Quality Rice					
Coefficients	-0.155**	-0.461**	0.308**		-0.056	
Standard Error	0.037	0.077	0.086		0.035	
P-Value	0.000	0.000	0.000		0.116	
Half-Life	4.116					
R^2 = 0.263; RMSE = 0.027; LL = 346.581; SBIC = -6.409; Lag = 2; Observations = 97						
	VECM for Domestic and Thai Prices of Low Quality Rice					
Coefficients	-0.012	-0.932**	0.152		0.163**	
Standard Error	0.021	0.217	0.098		0.051	
P-Value	0.577	0.000	0.118		0.001	
Half-Life	57.415					
R^2 = 0.156; RMSE = 0.032; LL = 331.402; SBIC = -6.722; Lag = 2; Observations = 97						
	VECM for Domestic and Pakistani Prices of Low Quality Rice					
Coefficients	-0.092**	-0.517**	0.045		0.159**	
Standard Error	0.0305	0.108	0.095		0.050	
P-Value	0.003	0.000	0.640		0.002	
Half-Life	7.182					
R^2 = 0.265; RMSE = 0.030; LL = 345.950; SBIC = -6.709; Lag = 2; Observations = 97						

Notes: ** and * denote 1% and 5% level of significance. α is the speed of adjustment; β is the cointegrating parameter; δ and θ are the short-run parameters of domestic and global rice prices, respectively. LL, RMSE and SBIC indicate Log Likelihood, Residual Mean Square Error, and Schwarz – Beyesian Information Criteria, respectively.

As can be observed in Table 6, domestic prices of high quality rice adjust faster to deviations from the long-run Afghan-Pakistani and Afghan-Thai equilibrium as compared to domestic prices of low quality rice. That is, as much as 16% and 9% of deviations from the long-run equilibrium between Afghan-Pakistani and Afghan-Thai prices of high quality rice are eliminated each period whereas about 9% and 1% of deviations from the long-run equilibrium between Afghan-Pakistani and Afghan-Thai prices of low quality rice are corrected each month, respectively. Hence, the time required for correcting 50% of deviations from the long-run equilibrium, i.e., half-life, is faster for high quality Pakistani (4 months) and Thai (8 months) rice prices as compared to low quality Pakistani (7 months) and Thai (57 months) rice prices. Indicating that arbitrage opportunities may be larger and remunerative in high quality rice markets than those of low quality rice as well as in closely situated markets than distant markets.[vii] In brief, the speed of adjustment and half-life are not only different between high and low quality rice prices, but also among their global reference prices.

Sharma (2003) reported that among the Asian countries studied excluding Thailand, rice markets in South Korea registered the maximum speed of adjustment to Thai 100% B (8%) while Philippines rice markets recorded the faster speed of adjustment to Thai A1 Super (7%). As compared to other Asian countries, Afghan markets of high, and low quality rice adjust faster to the global prices of high and low quality rice. Given the special condition of Afghanistan in terms of infrastructure, institutions and political instability, faster adjustment of its rice markets to changes in global prices implies that the functioning of domestic rice markets may have improved in the recent years.

3.4. The Effects of a Shock in Global Rice Prices on Domestic Rice Markets

The impulse response functions (IRFs) were estimated in this study to depict the effects of a one standard deviation unit shock in global rice prices on that of domestic prices. Panel (a), (b), (c), and (d) in Figure 3 show the effect of a shock in Thai prices of high quality rice (TPHQR), Pakistani prices of high quality rice (PPHQR), Thai prices of low quality rice (TPLQR) and Pakistani prices of low quality rice (PPLQR) on the corresponding domestic rice prices, respectively. It is evident from the Figure that Pakistani prices of high, and low quality rice have increasing and long-lasting effects on domestic prices of high and low quality rice, more so for PPLQR. This shows the influence of Pakistani rice prices on domestic markets in Afghanistan.

Furthermore, Thai prices of high and low quality rice have only transitory effects on domestic prices of high and low quality rice. The effect of a shock in TPHQR is dying out soon while that of TPLQR dissipates slowly but does not vanish completely. As compared to PPHQR and PPLQR, the effect of TPHQR and TPLQR is weaker, which again shows the dominant influence of Pakistani rice prices on Afghan rice markets. It should be noted that the effect of a shock in Pakistani and Thai prices of low quality rice is stronger on that of domestic prices as compared to their high quality counterparts affecting domestic prices of high quality rice.

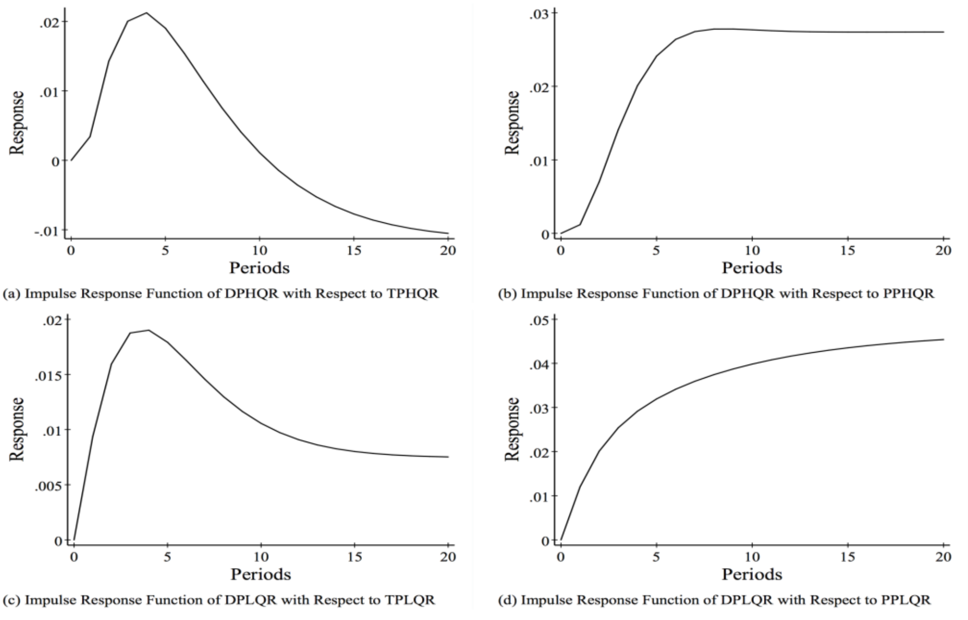

Figure 3. Impulse Response Functions

4. Conclusions and Policy Implications

The effect of a structural break was observed on unit root and cointegration tests. Although Perron (1989) showed that the standard unit root tests are biased towards non-rejection of a false null hypothesis, Lee and Strazicich unit root test confirmed that ADF and PP unit root tests wrongly rejected a true null hypothesis in a few price series. Moreover, the pairs of domestic and global prices of low quality rice showed no long-run relationship in the absence of a structural break, but they were cointegrated after allowing for a structural break in the level of price series. Thus, it may be important to allow for a possible structural break while testing for unit roots and cointegration (Perron 1989; Johansen *et al.*, 2000). Furthermore, the global and domestic prices of low quality rice appeared to be more volatile than their high quality counterparts. Indicating a higher level of uncertainty in low quality rice markets that may have negative impact on the welfare of the poor consumers.

Interestingly, the dynamics of price transmission is reported to be different between high and low quality rice markets with the latter being strongly affected by swings in global rice prices. While the extent of price transmission is larger with respect to the global prices of low quality rice, the speed of adjustment to the long-run Afghan-Thai and Afghan-Pakistani equilibrium is faster for domestic prices of high quality rice. This reveals that a shock in global rice prices may increase demand for low quality rice more than high quality rice, implying higher extent of price transmission in the context of a net rice importing country. Also the arbitrage opportunities may be larger and remunerative in high quality rice markets, which means a faster speed of adjustment for high quality rice prices. However, the effect of a shock in Pakistani and Thai prices of low quality rice is stronger on that of domestic prices as compared to their high quality counterparts affecting domestic prices of high quality rice.

The results imply that segmenting rice markets in studying price transmission may improve our understanding of their functioning and enhance the effectiveness of policy decisions regarding reducing the vulnerability of poor households to shocks in rice prices. Moreover, to stabilize domestic rice prices and reduce its effects on the poor people during a price shock, the dynamics of changes in high and low quality rice prices in domestic, global and supplier countries shall be closely monitored. In addition, improving the functioning of domestic rice markets, diversifying the sources of imports, increasing rice productivity and supporting rice farmers may be helpful for stability of rice markets in the long-run.

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[i] Rice is the second major staple food in the country, which together with wheat can play an important role in enhancing national food security. The observed behavior of poor Afghan consumers is such that they substitute rice for wheat if price of the latter goes up and vice versa. However, a relatively little attention and resources are devoted to develop rice farming and processing facilities in the country.

[ii] The poor people largely consume low quality rice while those of rich consume high quality rice. For example, Thai A1 Supper rice, low quality rice, is the main staple of African countries. It is the global prices of low quality rice that will have ramifications for poor people in developing countries.

[iii] Jamora and von Cramon-Taubadel (2012) showed that Thai 100% B and Thai 5% broken are cointegrated in the high quality cluster whereas Viet 25%, Thai 25%, Pak 25%, and Viet 5% broken in the low quality cluster follow the same long-run trend. This support our choice of the global reference prices for high and low quality rice categories.

[iv] For example, if we consider June 2008 as a break point, we would have a total of 18 observations in the first regime (from January 2007 to June 2008). First difference and lag order would have further reduced the number of observations, which in turn lowers the power of hypothesis tests and reliability of results.

[v] As the speed of adjustment coefficient corresponding to Thai prices of low quality rice is not significant, it indicates that the relationship between domestic and Thai prices of low quality rice may be weakly exogenous. Hence, the higher extent of price transmission of a change in Thai prices of low quality rice, i.e., 93%, may be the result of some other exogenous factors that have influenced the relationship between Afghan and Thai prices of low quality rice.

[vi] This behavior may be influenced by the recent food price crisis. We assume that spikes in global food prices further increases demand for low quality rice as a large part of consumers of high and medium quality rice will also shift to low quality rice after its price reach a certain level, which in the context of a poor net food importing country, translates to increased imports of low quality rice. Hence, a larger extent of price transmission may be expected for low quality rice prices as compared to those of high quality rice under price shocks.

[vii] Pakistan being a closer major rice supplier to Afghanistan, domestic prices of high and low quality rice adjust faster to those of Pakistani prices as compared to those of Thai.