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A comparison of asymmetric price transmission from global to domestic markets between high and low quality grains: a case of Afghan rice markets

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Abstract

This study compares the magnitude of price transmission and speed of adjustment towards equilibrium between global and domestic prices of high and low quality rice under asymmetric equilibrium adjustment. The dynamics of price transmission are examined using asymmetric vector error correction models. A structural break is considered in testing for unit roots and cointegration. Interestingly, the findings indicate that the magnitude of price transmission and speed of adjustment may be different between high and low quality rice prices. The speed of adjustment may be faster for high quality rice prices whereas the magnitude of price transmission appears to be greater for those of low quality rice. Moreover, domestic prices of high and low quality rice exposed asymmetric adjustment to divergence from the long-run equilibrium with adjustment being faster and significant to positive than negative deviation from the equilibrium. It is also observed that the Granger causality possibly runs from global to domestic rice prices. The results implies that considering rice as a differentiated commodity in the price transmission analysis may improve our understanding of the relationship between global and domestic rice markets and enhance the effectiveness of policy proposals for developing the rice markets and reducing the vulnerability of the poor households to shocks in the rice markets.

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1. Introduction

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 global prices of grains (rice, wheat and maize) experienced dramatic swings in the recent decade, which have been transmitted in varying magnitudes to domestic markets (Conforti 2004; Minot 2011; Ghoshray 2011; Greb *et al.* 2012; Hassanzoy *et al.* 2015). The transmission of these shocks to domestic markets has deteriorated the welfare of poor households in many developing countries (Hoyos and Medvedev 2009; FAO 2008). As a net food importer with a low financial and institutional capacity to counter enormous increases in food prices and the prevalence of food insecurity and poverty, Afghanistan is considered as a vulnerable country to shocks in global food prices (World Bank 2013).

Rice is the major staple food crop after wheat in Afghanistan that accounts for approximately 8% of the daily calorie intake (2,100 Kcal) with a per capita consumption of about 17 kg/year averaged over 2003/04 to 2013/14.[1] It is largely produced in the northern and eastern provinces of the country. Paddy (rice) is grown on around 5% of the total area under cereals and it accounts for almost 7% of the total cereals production averaged over 2005/06 to 2014/15. The domestic supply of rice is relatively more volatile than its consumption as reflected in a coefficient of variation of 24% and 13% during 1961/62 to 2013/14, respectively. Furthermore, the aggregate demand for rice in the country is about 491 thousand tonnes averaged over 2005/06 to 2014/15 with almost 11% of deficit (self sufficiency rate = 89%), which is met by commercial imports. Due to the persistent deficit in rice production, the country strongly depends on rice imports for meeting the increasing demand of its domestic markets. Historical data show that the rice imports in-flow to the country started during the early 1990s and reached to its historically high level (272,000 tonnes) in 2001/02. Pakistan has been the leading 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. The remaining is imported from other countries including Thailand (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 (Hassanzoy *et al.* 2015).

In a perfectly competitive marketing environment, the magnitude of price transmission will remain intact regardless of whether the change in price implies an increase or a decrease, i.e., adjustment is symmetric (Goletti and Babu 1994). However, agricultural markets, including those of rice, suffer from imperfections and are characterized by asymmetric adjustment. In addition to factors such as transaction costs, government interventions and market power (Meyer and von Cramon-Taubadel 2004), the existence of various quality clusters of an agricultural commodity such as rice may result in asymmetric price adjustment (Ghoshray 2002). If price adjustment is asymmetric, the standard cointegration tests and their extensions are misspecified (Enders and Siklos 2001). Nevertheless, we did not come across empirical studies that consider asymmetry in price transmission from global to domestic markets between high and low quality rice. Furthermore, the effect of a structural break on unit root and cointegration tests is well known (Perron 1989; Johansen *et al.* 2000) but it is frequently overlooked in the earlier research works.

[1] Rice is the second major staple food crop 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 the price of the latter goes up and vice versa. However, relatively little attention and resources are devoted to developing rice farming and processing facilities in the country.

The transmission of grain prices from global to domestic markets is studied extensively after the dramatic spikes in global food prices of 2007-2008 (e.g., Conforti 2004; Minot 2011; Ghoshray 2011; Greb *et al.* 2012; Hassanzoy *et al.* 2015) but no study has been conducted on Afghanistan's rice markets that accounts for asymmetric equilibrium adjustment. Rice is a differentiated product and rice market is highly segmented (Jamora and von Cramon-Taubadel 2012; Rakotoarisoa 2006; Agcaoili-Sombilla and Rosengrant 1994). The disparities in consumers' preferences and income levels in importing countries restrict the substitution among different qualities of rice (Cramer *et al.* 1993; Ghoshray 2008). However, previous studies on price transmission from global to domestic markets do not consider rice as a differentiated commodity, hence merely drawing on the 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, the 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.[2] However, the differences in the magnitude 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. With this background in mind, the present research has two main objectives. First, to examine the long-run relationship among global and domestic markets of high and low quality rice accounting for a structural break and asymmetric adjustment. Second, to compare the magnitude of price transmission and speed of adjustment towards the equilibrium between global and domestic prices of high and low quality rice under asymmetric adjustment between the rice markets.

2. Data and methods

2.1) Data used in analysis

The data used in the analysis comprise monthly data on global and domestic rice prices, consumer price indices (CPIs) and exchange rates covering a period from January 2007 to March 2015. Annual time series on rice production, consumption, and imports were also used to complement the analysis (see Appendix 1 for more details about the data series). All the price series were converted to real US dollar using CPIs of the corresponding country. The logarithmic form of the price series is used in the entire process of data analysis.

Jamora and von Cramon-Taubadel (2012) found that the rice export market is segmented and that there is no single rice grade that can best represent the global (world) rice prices.[3] Thus, in the present study, milled rice is divided into high and low quality clusters on the basis of the length and composition of rice kernels. As such, 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. 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.

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

[3] They 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 supports our choice of the global reference prices for high and low quality rice categories.

2.2) Trends in Global and Domestic Prices of High and Low Quality Rice

The global and domestic prices of high and low quality rice experienced a dramatic swing between January 2007 and June 2008 when Thai 100% B, Pakistani Basmati, Sela (high quality domestic rice), Thai 25% broken, Pakistani 25% broken and Permal (low quality domestic rice) rice prices swung up (in real terms) by 176%, 57%, 85%, 180%, 153% and 66%, respectively. Pattern of changes in global and domestic (real) prices of high and low quality rice is presented in Appendix 2. The Figure (Appendix 2) portrays that domestic prices of high and low quality rice follow changes in their corresponding global reference prices but the price level and magnitude of price volatility are different. Moreover, the Figure also shows that global and domestic prices of low quality rice may be more volatile than their high quality counterparts. This indicates a higher level of uncertainty in low quality rice markets that may have negative impact on the welfare of the poor consumers (Hassanzoy *et al.* 2015).

2.3) Methods of analysis

Perron (1989) argues that in the presence of a structural break, the standard unit root tests are biased towards non-rejection of a false unit root hypothesis. The recent enormous increases in global food prices of 2007-2008 may have caused a break in the prices series. Thus, the non-stationarity property and order of integration of the price series is examined using Lee and Strazicich (2003) unit root test (LS test) with a structural break in level (Model A) as well as both in level and trend (Model C). Unlike other unit root tests with structural breaks, LS test endogenously determines the break points and allows for a structural break under both null and alternative hypothesis.

The long-run equilibrium relationship between the pairs of global and domestic rice prices was tested using the threshold cointegration method of Enders and Siklos (2001), as in Equation (4), and the maximum likelihood cointegration test of Johansen *et al.* (2000). The latter test is a generalization of Johansen (1988, 1996) cointegration test and allows for up to two breaks in level at a known point in time. Since Johansen *et al.* (2000) test examines hypothesis corresponding to the Model A, the break points reported by the Model A of LS test for level of the global (Thai and Pakistani) prices of high and low quality rice were assumed to be the locations of structural breaks in the price series (Table I). The general form of Johansen *et al.* (2000) cointegration model with intercept restricted to the cointegrating vector is as follows:

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

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; 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; and $D_{j,t-i}$ 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 2) was employed to estimate the number of cointegrating equations between global and domestic prices of high and low quality rice.

$$\lambda_{trace}\,(r) = -T \sum_{i=r+1}^{n} \ln\left(1 - \hat{\lambda}_i\right) \qquad (2)$$

Enders and Siklos (2001) argue that the standard cointegration tests, e.g., Engle and Granger (1987) and Johansen (1988, 1996), and their extensions assume linearity and symmetric adjustment that are misspecified if adjustment is asymmetric. Thus, asymmetric error correction model with a threshold adjustment (Equation 5) was estimated for each pair of domestic and global prices of high and low quality rice using the two-step procedure developed by Enders and Granger (1998) and extended by Enders and Siklos (2001). The first step involves estimating the long-run relationship between the pairs of I(1) price series as the equation below:

$$P_t^d = \alpha_0 + \beta P_t^g + \varepsilon_t \qquad (3)$$

where, P_t^d and P_t^g are logarithm of real domestic and global rice prices, respectively; β is the cointegrating coefficient; and ε_t is the disturbance term, which may be serially correlated.

In the second step, the estimated residuals from Equation (3) are examined for non-stationarity using the following alternative unit root test with asymmetric adjustment, i.e., threshold autoregressive model (TAR), proposed by Enders and Granger (1998):

$$\Delta\hat{\varepsilon}_t = I_t\rho_1\hat{\varepsilon}_{t-1} + (1 - I_t)\rho_2\hat{\varepsilon}_{t-1} + \sum_{i=1}^{p-1} \delta_i \Delta\hat{\varepsilon}_{t-i} + \omega_t \qquad (4)$$

where, I_t is the Heaviside indicator function such that $I_t = 1$ if $\hat{\varepsilon}_{t-1} \geq 0$ and $I_t = 0$ if $\hat{\varepsilon}_{t-1} < 0$ (0 is the threshold value); ρ_1, ρ_2 and δ_i are coefficients of the model; and ω_t is i.i.d. disturbance term. If the null hypothesis $\rho_1 = \rho_2 = 0$ is rejected, $\hat{\varepsilon}_t$ is said to be stationary implying that the pair of prices in Equation (3) are cointegrated with a threshold adjustment. Upon confirmation of the cointegration between the pairs of rice price series, an asymmetric vector error correction model with a threshold adjustment, as below, was estimated following Sun (2011):

$$\Delta P_t^d = \mu_0 + \alpha^+ E_{t-1}^+ + \alpha^- E_{t-1}^- + \sum_{j,i=1}^{p-1} \delta_j^+ \Delta P_{t-i}^{d+} + \sum_{j,i=1}^{p-1} \delta_j^- \Delta P_{t-i}^{d-} + \sum_{j,i=1}^{p-1} \theta_j^+ \Delta P_{t-i}^{g+} + \sum_{j,i=1}^{p-1} \theta_j^- \Delta P_{t-i}^{g-} + \nu_t \qquad (5)$$

where, ΔP_t^d is the first difference of the logarithm of real domestic rice prices; P^d and P^g have the same meaning as in Equation (3); α^+, α^-, δ_j^+, δ_j^-, θ_j^+ and θ_j^- are parameters of the model; E_{t-1} stands for error correction term with + and – signs indicating positive and negative divergence from the long-run equilibrium, respectively; and ν_t is the i.i.d. disturbance term. Given the results of Granger causality (Table IV), only one-way price transmission, i.e., from global to domestic markets, is considered.

The standard F-test was employed to examine hypotheses regarding 'equilibrium adjustment path asymmetry', 'distributed lag asymmetry' (Frey and Manera 2007) and Granger causality. Although the null hypothesis of no asymmetric equilibrium adjustment path was not rejected at 10% level of significance in case of the low quality rice prices, it is rejected at less than 13% level of significance (Table IV). Hence, we estimated asymmetric error correction models for both high and low quality rice prices to compare the parameters of asymmetric price transmission between them. 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. Results and discussion

3.1) Unit root test 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. Hence, Lee and Strazicich (2003) unit root test (LS test) with a structural break in intercept (Model A) and in both intercept and slope (Model C) is estimated in level and the first difference of the price series. Akaike, Beyesian, and Hannan and Quinn information criteria are used to choose the appropriate lag order on the basis of similar results for at least two of the criteria. Table I summarizes the results of LS test for global and domestic prices of high and low quality rice. The Table shows that all the price series have a unit root or are non-stationary in level whereas they are stationary in the first difference in case of both Model A and Model C. This indicates that the domestic and global prices of high and low quality rice are differenced-stationary and integrated of the same order or I(1). The test also confirmed the occurrence of a structural break in the price series, which may be induced by the dramatic spikes in global food prices of 2007-2008.

Table I: 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
		Lee and Strazicich Unit Root Test in 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
		Lee and Strazicich Unit Root Test in the 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 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, Bayesian, 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).

3.2) Cointegration and long-run 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 and 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. The long-run equilibrium relationship between the pairs of rice prices is examined using Johansen *et al.*

(2000) cointegration test with a level shift and threshold cointegration test of Enders and Siklos (2001) that allows for asymmetric adjustment. Akaike, Beyesian, and Hannan and Quinn information criteria were used to choose the appropriate lag order based on the rule that at least two of the criteria should select similar lag order.

The results of Johansen *et al.* (2000) cointegration test with a single level shift are provided in Table II. It is evident from the Table 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% level of significance, respectively. Although two cointegrating equations are reported between domestic and Pakistani prices of high quality rice at the 5% level, it is not valid since the number of cointegrating vectors will always be one less than the number of variables, i.e., $r = n - 1$. Hence, a long-run equilibrium relationship exists between the pairs of high quality global and domestic rice prices. Similarly, 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. In a nutshell, the pairs of domestic and global prices of high and low quality rice may diverge in the short-run, but they converge towards equilibrium in the long run as a result of arbitrage, substitution or both (Ghoshray 2008).

Table II: Results of Johansen's Cointegration Tests 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, Bayesian, and Hannan and Quinn information criteria. Intercept is restricted to the cointegrating vector. The figures in brackets are the corresponding shift dates. The full form of the abbreviations of price series is mentioned in notes under Table I.

Table III presents the results of threshold cointegration with a threshold value of zero. It can be seen from the Table that the pairs of global and domestic prices of high quality rice have a long-run equilibrium relationship with each other as the null hypothesis of no cointegration ($\rho_1 = \rho_2 = 0$) is rejected at less than 1% level of significance. As regards cointegration between the pairs of domestic and global prices of low quality rice, domestic and Pakistani prices of low quality rice are cointegrated whereas cointegration is absent between domestic and Thai prices of low quality rice. Meaning that domestic prices of high and low quality rice have a long-run equilibrium relationship with their corresponding global rice prices, except for Thai prices of low quality rice. The absence of cointegration between domestic and Thai price of low quality rice is, however, not supported by the results of Johansen *et al.* (2000) cointegration test (Table II).

It is often assumed that the landlocked countries with poor infrastructure, such as Afghanistan, are much less likely to be following the movements in global prices (Zorya *et al.* 2012). However, the results of cointegration tests reject this assumption in case of domestic markets of high and low quality rice as they are integrated to their respective global markets. Hassanzoy *et al.* (2015) reported similar results for rice markets in the country. Adoption of the market economy system in 2004 with the new constitution, structural adjustments, reconstruction of the "national ring road" and other secondary roads, lower tariff on imports with no quantitative trade restrictions and strong reliance on imports may have resulted in the integration of domestic rice markets to those of global markets. 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). Given the findings of our study, the possible reasons for lack of cointegration of Asian rice markets to that of global market may be, inter alia, ignoring a possible structural break, assuming non-segmented domestic rice markets, and ignoring asymmetric equilibrium adjustment path in testing for cointegration.[4] Factors such as poor infrastructure, high transaction costs, and trade distorting policies may also be responsible.

Table III: Results of Threshold Cointegration between the Pairs of Rice Price Series

Price Pairs	Lag	ρ_1	ρ_2	ϕ - Statistic ($H_0: \rho_1 = \rho_2 = 0$)
DPHQR – TPHQR	0	-0.096* (0.100)	-0.163*** (0.002)	6.310*** (0.003)
DPLQR – TPLQR	0	-0.110* (0.060)	-0.024 (0.673)	1.896 (0.156)
DPHQR – PPHQR	1	-0.233*** (0.001)	-0.182*** (0.007)	10.15*** (0.000)
DPLQR – PPLQR	0	-0.076 (0.167)	-0.118** (0.026)	3.514** (0.034)

Notes: ***, ** and * denote 1%, 5% and 10% level of significance, respectively. The lag order is selected using Bayesian information criterion. Figures in brackets are p-values of the corresponding estimates. Threshold = 0. The full forms of the abbreviations of price series is mentioned in notes under Table I.

3.3) Asymmetry and Granger causality tests

The adjustment path of domestic prices of high quality rice to deviations from the long-run Afghan-Thai and Afghan-Pakistani equilibrium is asymmetric at less than 10% level of significance. But, the test failed to reject the null hypothesis of no asymmetric equilibrium adjustment path of domestic prices of low quality rice to divergence from the long-run Afghan-Thai and Afghan-Pakistani equilibrium at the same level of significance. Ghoshray (2008) reported similar results for Thai and Vietnamese export prices of high and low quality rice. However, the null hypothesis can be rejected at less than 13% level of significance in the latter case (Table IV). It may be said that at 10% level of significance domestic prices of high quality rice adjust differently to positive and negative divergences from the long-run equilibrium while those of low quality rice adjust in a similar way. The asymmetry in high quality rice markets implies that these markets may not be perfectly competitive, which may be due to the market power exerted by major Thai and Pakistani rice exporters (Ghoshray 2008). This result may also hold with low quality rice markets if the significance level is extended from 10% to 13%.

[4] e.g., Sharma (2003) reported that Indonesian rice markets are not cointegrated with that of global markets whereas Ghoshray (2011) found that they are cointegrated with global rice markets using threshold cointegration that accounts for asymmetric equilibrium adjustment.

Distributed lag asymmetry is absent with respect to Pakistani and Thai prices of high and low quality rice at both 1 and 2 lag periods, respectively, whereas it is accepted with regard to own prices at 1 and 2 lagged periods. Furthermore, the Granger causality test suggested that Thai and Pakistani prices of high and low quality rice Granger cause domestic prices of high and low quality rice, but the opposite is not true (Table IV). This is why, only one-way price transmission, i.e., from global to domestic markets, is considered in the present study.

Table IV: Results of Asymmetry and Granger Causality Tests

Null Hypothesis	F-Statistic	P-Value
Domestic and Thai Prices of High Quality Rice		
$\alpha^{(+)} = \alpha^{(-)}$	3.068*	0.083
$\theta_1^{(+)} = \theta_1^{(-)}$	0.005	0.945
$\theta_2^{(+)} = \theta_2^{(-)}$	0.251	0.618
$\delta_1^{(+)} = \delta_1^{(-)}$	5.246**	0.024
$\delta_2^{(+)} = \delta_2^{(-)}$	0.094	0.759
TPHQR does not Granger cause DPHQR	4.682***	0.002
DPHQR does not Granger cause TPHQR	1.383	0.247
Domestic and Pakistani Prices of High Quality Rice		
$\alpha^{(+)} = \alpha^{(-)}$	3.711*	0.057
$\theta_1^{(+)} = \theta_1^{(-)}$	0.670	0.415
$\delta_1^{(+)} = \delta_1^{(-)}$	11.98***	0.001
PPHQR does not Granger cause DPHQR	2.402*	0.096
DPHQR does not Granger cause PPHQR	1.050	0.354
Domestic and Thai Prices of Low Quality Rice		
$\alpha^{(+)} = \alpha^{(-)}$	2.386	0.126
$\theta_1^{(+)} = \theta_1^{(-)}$	0.388	0.535
$\delta_1^{(+)} = \delta_1^{(-)}$	7.334***	0.008
TPLQR does not Granger cause DPLQR	3.386**	0.038
DPLQR does not Granger cause TPLQR	1.786	0.174
Domestic and Pakistani Prices of Low Quality Rice		
$\alpha^{(+)} = \alpha^{(-)}$	2.498	0.118
$\theta_1^{(+)} = \theta_1^{(-)}$	0.008	0.928
$\delta_1^{(+)} = \delta_1^{(-)}$	11.82***	0.001
PPLQR does not Granger cause DPLQR	5.398***	0.006
DPLQR does not Granger cause PPLQR	0.432	0.651

Notes: ***, ** and * denote 1%, 5% and 10% level of significance, respectively. $\theta_j^{(-)}$, $\theta_j^{(+)}$, $\delta_j^{(+)}$and $\delta_j^{(-)}$ are coefficients showing the effects of previous periods positive and negative changes in global and domestic rice prices on domestic rice prices. $\alpha^{(+)}$ *and* $\alpha^{(-)}$ are positive and negative error correction coefficients, respectively. The coefficients are estimated from the asymmetric error correction models for the pairs of rice prices (Table V). The full forms of the abbreviations of price series is mentioned in notes under Table I.

3.4) Asymmetric price transmission with threshold adjustment

Price transmission is considered to be symmetric if positive and negative changes in prices are transmitted in equal magnitude from one market to another market. However, factors such as transaction costs, government interventions, market power and existence of different qualities of an agricultural commodity may result in asymmetric spatial price transmission (Meyer and von Cramon-Taubadel 2004; Ghoshray 2008). It is shown in the previous section that domestic prices of high and low quality rice adjust asymmetrically to changes in the corresponding global rice reference prices at less than 13% level of significance.

The results of asymmetric price transmission between the pairs of domestic and global prices of high and low quality rice are presented in Table V. Domestic prices of high quality rice adjust to any positive deviation from the long-run Afghan-Pakistani and Afghan-Thai equilibrium while their adjustment to negative divergence from the equilibrium is statistically not significant. The error correction coefficients of -0.21 and -0.31 indicate that as much as 21% and 31% of a unit positive divergence from the long-run Afghan-Thai and Afghan-Pakistani equilibrium is corrected each month, respectively. The time required to eliminate 50% of positive deviations from the long-run Afghan-Thai and Afghan-Pakistani equilibrium is estimated about 3 and 2 months, respectively. This indicates that domestic prices of high quality rice respond faster to positive divergences from the long-run equilibrium between Afghan-Pakistani than Afghan-Thai prices of high quality rice.

It is evident from Table V that domestic prices of low quality rice adjust only to positive deviations from the long-run equilibrium between Afghan and Thai prices of low quality rice while they adjust merely to negative divergences from the long-run Afghan-Pakistani equilibrium. That is, approximately 16% of a unit positive and 23% of a unit negative deviation from the long-run Afghan-Thai and Afghan-Pakistani equilibrium is eliminated each month, respectively. In other words, it takes about 4 and 3 months to eliminate half of the positive and negative divergences from the long-run Afghan-Thai and Afghan-Pakistani equilibrium, respectively. This implies a faster adjustment of domestic prices of low quality rice to deviation from the long-run Afghan-Pakistani equilibrium as compared to divergence from the long-run Afghan-Thai equilibrium. Using symmetric vector error correction model, Hassanzoy *et al.* (2015) arrived at similar results that domestic prices of high and low quality rice adjust faster to their Pakistani than Thai counterparts.

In a nutshell, domestic prices of high and low quality rice adjust faster to positive divergences from the long-run relationship as compared to negative deviations with Pakistani prices of low quality rice being the only exception.[5] This suggests that imperfections such as concentration may exist in the rice markets because traders/firms may be willing to adjust faster to price changes that expand their margins than to those that squeeze their margins (Goletti and Babu 1994; Ghoshray 2002, 2011). Furthermore, the magnitude of adjustment to positive and negative divergences from the long-run equilibrium is larger to changes in Pakistani (30%, 6%) and Thai (21%, 3%) prices of high quality rice as compared to Pakistani (1%, 23%) and Thai (16%, 2%) prices of low quality rice. This implies that arbitrage opportunities may be larger and remunerative in high quality rice markets than those of low quality rice as well as in closely located markets than distant markets. However, the negative and positive coefficients of speed of adjustment are statistically only significant and non-significant for Pakistani prices of low quality rice, respectively (Table V).

The elasticity of price transmission with respect to Thai 100% B, Pakistani Basmati, Thai 25% broken and Pakistani 25% broken is, respectively, estimated at 18%, 29%, 35% and 30% from the long-run regression (Table V). This suggests that changes in the global

[5] The faster adjustment of domestic prices of high and low quality rice to divergences from the long-run Afghan-Pakistani equilibrium may be due to the closeness and influence of Pakistani rice markets on domestic rice markets.

Table V: The Results of Asymmetric Vector Error Correction Models (AVECM)

Coefficient	Estimate	Std. Error	P-Value	Half-Life	EPT (t-value)
AVECM for Domestic and Thai Prices of High Quality Rice					
$\theta_1^{(+)}$	0.080	0.063	0.209	-	
$\theta_2^{(+)}$	0.135**	0.065	0.040	-	
$\theta_1^{(-)}$	0.071	0.090	0.429	-	
$\theta_2^{(-)}$	0.075	0.089	0.403	-	
$\delta_1^{(+)}$	0.430***	0.160	0.009	-	0.188***
$\delta_2^{(+)}$	0.222	0.152	0.148	-	(5.191)
$\delta_1^{(-)}$	-0.207	0.180	0.253	-	
$\delta_2^{(-)}$	0.136	0.183	0.460	-	
$\alpha^{(+)}$	-0.212***	0.065	0.002	2.909	
$\alpha^{(-)}$	-0.030	0.059	0.610	22.76	
$\bar{R}^2$ = 0.340; RMSE = 0.024; SBIC = -398.254; F-Stat. = 5.9 (p-value = 0.000); Lag = 2; Obs. = 96					
AVECM for Domestic and Pakistani Prices of High Quality Rice					
$\theta_1^{(+)}$	-0.101*	0.052	0.057	-	
$\theta_1^{(-)}$	-0.034	0.053	0.528	-	
$\delta_1^{(+)}$	0.689***	0.132	0.000	-	0.287***
$\delta_1^{(-)}$	-0.244	0.187	0.196	-	(6.962)
$\alpha^{(+)}$	-0.308***	0.079	0.000	1.875	
$\alpha^{(-)}$	-0.056	0.073	0.440	12.03	
$\bar{R}^2$ = 0.335; RMSE = 0.025; SBIC = -413.034; F-Stat. = 9.1 (p-value = 0.000); Lag = 1; Obs. = 97					
AVECM for Domestic and Thai Prices of Low Quality Rice					
$\theta_1^{(+)}$	0.094	0.071	0.191	-	
$\theta_1^{(-)}$	0.177*	0.097	0.072	-	
$\delta_1^{(+)}$	0.535***	0.160	0.001	-	0.357***
$\delta_1^{(-)}$	-0.301	0.205	0.146	-	(8.339)
$\alpha^{(+)}$	-0.164*	0.073	0.027	3.870	
$\alpha^{(-)}$	0.021	0.066	0.749	-33.35	
$\bar{R}^2$ = 0.203; RMSE = 0.030; SBIC = -373.267; F-Stat. = 5.1 (p-value = 0.000); Lag = 1; Obs. = 97					
AVECM for Domestic and Pakistani Prices of Low Quality Rice					
$\theta_1^{(+)}$	0.164*	0.084	0.055	-	
$\theta_1^{(-)}$	0.153**	0.075	0.043	-	
$\delta_1^{(+)}$	0.456***	0.144	0.002	-	0.296***
$\delta_1^{(-)}$	-0.536***	0.199	0.009	-	(10.04)
$\alpha^{(+)}$	-0.005	0.079	0.948	138.3	
$\alpha^{(-)}$	-0.227***	0.080	0.005	2.692	
$\bar{R}^2$ = 0.311; RMSE = 0.028; SBIC = -387.369; F-Stat. = 8.2 (p-value = 0.000); Lag = 1; Obs. = 97					

Notes: ***, ** and * denote 1%, 5% and 10% level of significance, respectively. $\theta_j^{(-)}$, $\theta_j^{(+)}$, $\delta_j^{(+)}$ and $\delta_j^{(-)}$ are coefficients showing the effects of previous periods positive and negative changes in global and domestic rice prices on domestic rice prices. $\alpha^{(+)}$ *and* $\alpha^{(-)}$ are positive and negative error correction coefficients, respectively. EPT stands for elasticity of price transmission. Lag (VECM) = Lag (VAR) – 1 prices of low quality rice are transmitted in a greater extent to domestic markets as compared to those of high quality rice. This behavior may be influenced by the recent food price crisis.[6] This result is consistent with that found by Hassanzoy *et al.* (2015).

As regards short-run dynamics, it can be seen from Table V that domestic prices of high quality rice are affected by positive changes in Thai and Pakistani prices of high quality rice after a period of two and one month(s), respectively, but the effect of negative changes is not significant. However, the results are mixed in case of domestic prices of low quality rice. That is, only negative changes in Thai, but both positive and negative changes in Pakistani prices of low quality rice affect domestic prices of low quality rice at a similar lag period of one month. In addition, domestic prices of high quality rice merely respond to previous period positive changes in its own prices caused by changes in Thai and Pakistani prices of high quality rice at 2 and 1 lag period, respectively, while showing no response to negative change with Pakistan prices of low quality rice being the only exception. It is evident that positive and negative lagged changes in Thai and Pakistani prices of low quality rice have stronger effect on domestic prices of low quality rice as compared to the effect of previous periods positive and negative changes in Thai and Pakistani prices of high quality rice on their domestic counterparts.

4. Conclusions and implications

The domestic prices of high and low quality rice showed a long-run equilibrium relationship with their corresponding global reference prices. This implies that the high and low quality rice markets in Afghanistan may be efficient as they follow movements in the global prices of high and low quality rice in the long-run. However, given the landlocked situation and poor infrastructure of the country coupled with a single major supplier who can impose export restriction, i.e., Pakistan, and political instability, the long-run relationship may be at risk under a spike in global food prices. Hence, short-run and long-run policy measures shall be adopted to improve the functioning and stability of rice markets in the country.

Interestingly, the results indicate that high and low quality rice prices are different in the magnitude of price transmission and speed of adjustment. Hence, considering rice as a differentiated commodity in the spatial price transmission analysis can improve our understanding of the linkages between global and domestic rice markets (Jamora and Taubadel 2012). This may also enhance the effectiveness of policy recommendations for improving the functioning of rice markets and reducing the vulnerability of poor households to shocks in rice prices (Rakotoarisoa 2006). However, the long-run elasticity of price transmission showed that changes in global prices of low quality rice are transmitted in a greater extent to domestic markets as compared to those of high quality rice. Moreover, domestic markets of high and low quality rice are not perfectly competitive, as they adjust differently to positive and negative deviations from the long-run equilibrium at less than 13% level of significance. This may be due to, *inter alia*, the market power exerted by major rice exporters to the country, especially Pakistan. Likewise, domestic prices of high and low quality rice adjust faster to positive divergences from the long-run relationship than negative deviations, Pakistani prices of low quality rice being the only exception. However, the magnitude of adjustment to positive and negative divergences from the long-run equilibrium is larger to changes in high quality rice prices as compared to those of low quality rice. This

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[6] We assume that spikes in global food prices further increase demand for low quality rice as a large part of middle and low income consumers of high quality rice will also shift to low quality rice after its price reaches a certain threshold, which in the context of a poor net 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. The results of Hassanzoy *et al.* (2015) also support this assumption. However, more in-depth study of consumers' behavior may be required to empirically test this assumption.

suggests that the arbitrage opportunities may be larger and remunerative in high quality rice markets. Finally, Thai and Pakistani prices of high and low quality rice Granger cause domestic prices of high and low quality rice, but the opposite is not true.

The larger magnitude of price transmission and lower speed of adjustment of domestic prices of low quality rice implies that the effect of a shock in global prices may be strong and lasting on domestic prices of low quality rice than that of high quality rice in the context of a net food importing country such as Afghanistan. This is also consistent with Hassanzoy *et al.* (2015). Thus, to mitigate the effects of a shock in global rice prices on poor households, the low quality rice prices shall be closely monitored and efforts shall be made to improve the functioning and stability of rice markets.

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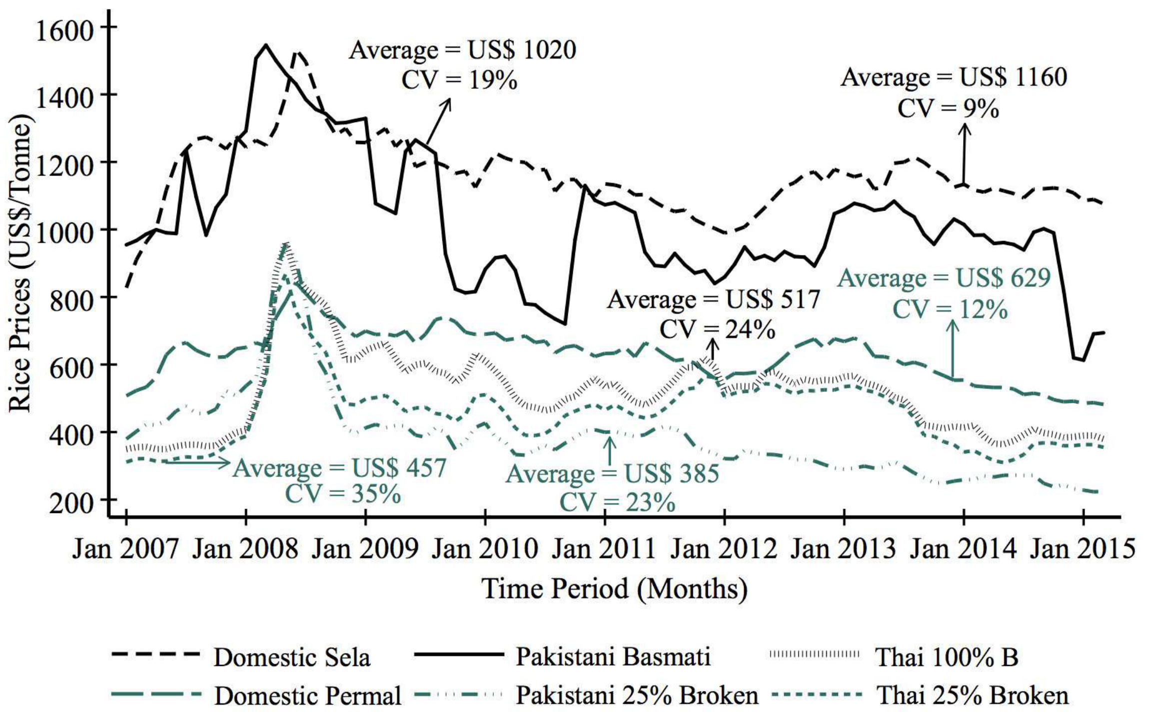
Appendix 1: Description of Data Series Used in This Study

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* Agricultural Prospects Reports (2005/06 to 2014/15), Ministry of Agriculture, Irrigation and Livestock of Afghanistan



Appendix 2: Pattern of Changes in Global and Domestic (Real) Prices of High and Low Quality Rice: January 2007 to March 2015.