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Spatial Market Integration and Price Transmission among High and Low Quality Rice Markets in Afghanistan

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This research examines cointegration and dynamics of price transmission among domestic as well as domestic & global and domestic & major supplier's markets of high and low quality rice; and compares the magnitude of price transmission and speed of adjustment between the high and low quality rice markets. Unit root tests, the consistent momentum threshold autoregressive (M–TAR) models and vector error correction models (symmetric and asymmetric) are employed in this study. The results showed that the provincial markets of high and low quality rice are cointegrated with their respective market of Kabul, exception being Kandahar and Maimana markets of low quality rice. They are also cointegrated with their corresponding Pakistani and global markets. Evidence of short– and long–run asymmetric adjustment among the provincial markets of high and low quality rice with respect to their corresponding Kabul, Pakistani and global markets indicates the presence of persistent and temporary inefficiencies in the rice markets. The short– and long–run speed of adjustment coefficients are relatively larger for high than low quality rice markets, implying efficient and/or remunerative spatial arbitrage in the high quality rice markets. Conversely, the elasticity of price transmission is relatively greater for the majority of low than high quality rice markets pairs. A random shock in Kabul, Pakistani and global markets of high and low quality rice affect their respective provincial markets in varying degrees. In a nutshell, the dynamics of price transmission may be different between the pairs of high and low quality rice markets. This paper illuminates the dynamics of spatial price transmission among the segmented rice markets and emphasizes the need for improving the functioning of rice markets in the country using an integrated approach.

Key words: Afghanistan, High and low quality rice markets, Market integration, Price transmission

INTRODUCTION

The government of Afghanistan adopted free trade policy since around a decade ago and the country became the 164th member of the World Trade Organization (WTO) on July 29, 2016. It has by far been one of the developing countries that have the least trade distorting policies. These trade liberalization processes expose, *inter alia*, Afghan farmers to greater competition from abroad. This may challenge, among others, rice productivity and production growth, commercialization of the subsistence and semi–subsistence rice farming and development of a modern rice processing industry because of the absence of appropriate price incentives and competitiveness. As a result, the country would continue to depend on rice imports for many years to come. An integrated approach may be needed to address the challenges and move the country towards self–sufficiency in rice production and enhance food security. Such an integrated approach should aim at improving productivity and quality of local rice, establishing modern rice processing mills, enhancing market integration and adopting trade policy measures. The third component, i.e., enhancing market integration, is the focus of this research, which is also essential for the realization of the remaining dimensions.

The basic question is how will well–integrated rice markets demonstrate their usefulness in mitigating the aforementioned challenges due to trade liberalization. Improving market integration is very important to the development of rice sector, raising income of farmers and maintaining food security in the country. The degree to which rice farmers will benefit from the trade liberalization partly depends on the efficiency of rice markets in transmitting the right price signals and incentives to farmers and other market participants. Rice is carried from the surplus to the deficit regions provided that markets in the surplus and deficit regions are integrated and the arbitrage is profitable. Although integration of domestic and global rice markets may ensure stabilization of domestic rice markets when the domestic production is deficient, it can also expose domestic markets to the effects of global price shocks and trade distorting policies. A successful implementation of price–based agricultural policies relies on a well–functioning market. Moreover, a knowledge of the price transmission dynamics among the rice markets assists policy makers and practitioners in better understanding of the structure and functioning of rice markets. Promoting the commercialization of rice farming in Afghanistan requires, among others, substitution of a price or profit incentive for the subsistence incentive of farmers, which may not be attainable in the absence of an efficient agricultural market and enabling

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policy environment.

Cointegration and price transmission among the rice markets have been researched extensively after the so–called food price crisis of 2007–2008. The studies can be divided into three groups: (1) studies that focus on domestic markets and their relations with the global market (e.g., Baulch *et al*., 2008; Ghoshray, 2011; Minot, 2011; Ahmad and Gjølberg, 2015; Hassanzoy *et al*., 2015, 2016); (2) studies that focus only on the relationship between the exports markets (e.g., Ghoshray, 2008; Chulaphan *et al*., 2013; John, 2014); and (3) among these two categories are studies that considered rice market to be segmented into high and low quality markets in cointegration and price transmission analyses (e.g., Ghoshray, 2008; Hassanzoy *et al*., 2015, 2016). Regarding the rice markets in Afghanistan, Hassanzoy *et al*. (2015, 2016) examined cointegration and price transmission among domestic and global markets of high and low quality rice. They also analyzed the price transmission dynamics among domestic and Pakistani markets of high and low quality rice, the latter being the largest supplier of rice to Afghanistan. However, they neither considered cointegration and price transmission among the major provincial markets of high and low quality rice in the country, nor their relationship with the corresponding Pakistani and global markets. Moreover, the difference in the magnitude of price transmission and speed of adjustment towards equilibrium between the major provincial markets of high and low quality rice has not been studied. We did not come across any study that compared the dynamics of price transmission between the domestic markets of high and low quality rice in other countries, either. Considering rice as a differentiated commodity improves analysis of the spatial price linkages and enhances the effectiveness of policy recommendations for developing the rice markets and reducing the vulnerability of poor people to price shocks (Hassanzoy *et al*., 2015, 2016).

In a perfectly competitive marketing environment, the magnitude of price transmission will remain intact regardless of whether the change in prices implies an increase or a decrease, i.e., adjustment is symmetric (Goletti and Babu, 1994). In reality, agricultural markets, including those for rice, suffer from imperfections and are characterized by asymmetric adjustment. Enders and Siklos (2001) argue that the standard cointegration tests and their extensions are misspecified if adjustment towards the long–run equilibrium is asymmetric. Factors such as market power, transaction costs, differentiated nature of agricultural products such as rice, government interventions, asymmetric information, menu costs and stock–holding behavior may result in asymmetric adjustment towards the long–run equilibrium (Abdulai, 2000; Meyer and von Cramon–Taubadel, 2004; Ghoshray, 2008; Ankamah–Yeboah, 2012). Although some of these factors such as high transaction costs, the influential market power of the major supplier country (Pakistan) and large Afghan traders, quality differences of rice and asymmetric information may result in asymmetric equilibrium adjustment in the context of Afghanistan, no empirical studies have been carried out to examine asymmetric price transmission and threshold cointegration among the major provincial rice markets in the country as well as their relationship with the respective Pakistani and global markets. Thus, the present study is designed to account for the above mentioned gaps in the literature.

With this background in mind, the present research has the following pair of objectives. First, it examines the long–run equilibrium relationship and dynamics of price transmission among domestic as well as domestic & global and domestic & major supplier's markets of high and low quality rice. Second, it compares the magnitude of price transmission and speed of adjustment between domestic as well as domestic & global and domestic & major supplier's markets of high and low quality rice.

An overview of rice production, consumption and trade in Afghanistan

Rice is the major staple food-grain after wheat in Afghanistan that accounted for approximately 8% of the daily calorie intake (2,100 Kcal) with the per capita consumption of about 17 kg/year averaged over 2003/04–2013/14. It is largely produced in the northern and eastern provinces of the country. Kunduz, Baghlan, Takhar, Nangarhar and Lagman (Figure 2) are among the major rice producing provinces in the country that accounted for 32%, 20%, 15%, 8% and 7% of the total rice production in the country during 2011/12–2015/16, respectively. Paddy is grown on around 6% of the total area under cereals and it accounts for almost 8% of the total cereals production averaged over 2005/06–2014/15. On average, during 2001/02–2013/14, the country consumed about 493,303 tonnes of milled rice of which 358,727 tonnes (73%) is produced domestically and the remaining 134,394 tonnes (27%) is imported from abroad, mostly from Pakistan. During the past two and a half decades or so, the per capita consumption, production and imports of rice in the country increased by 1.2%, 3.2% and 5.2% per year, respectively. Afghanistan is not a major producer, consumer and importer of rice in the world as it is ranked 44th, 69th, and 49th with respect to rice production, per capita consumption and imports during 2000/01–2013/14, respectively.

Due to the persistent deficit in rice production, subsistence and semi–subsistence rice farming and low quality of local rice varieties, Afghanistan substantially depends on rice imports for meeting the increasing demand of its growing population. On average, the country annually spent approximately 70 million USD (about 1.4% of agricultural GDP) to import 218 thousand tonnes of rice each year during 2013/14–2015/16. Pakistan has been the leading supplier of rice to Afghanistan that accounted for 80% (45,018 tonnes) of the total high quality (56,525 tonnes) and 99% (159,699 tonnes) of the total low quality (161,657 tonnes) rice imports during the same period. Our field survey of the rice markets, however, revealed that almost all of the imported rice is supplied by Pakistan, except for meager imports from elsewhere like India. Although some brands of rice are sold under the name of other countries such as India, they are indeed Indian rice varieties produced in Pakistan (Own survey, 2016).[3]

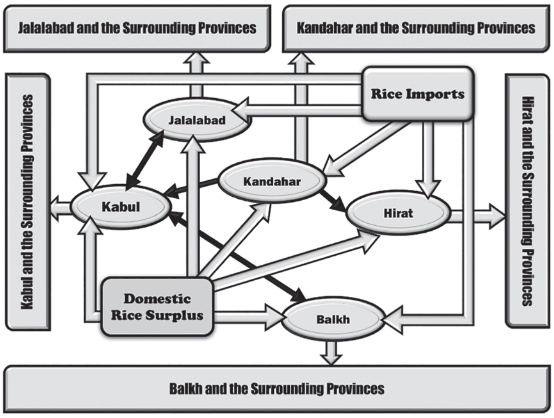

Fig. 1. The structure of rice markets and trade in Afghanistan.
Source: Own survey

The supply of rice in Afghanistan comprises national marketable surplus of rice plus rice imports. It was observed during the field survey that local rice is very scarce in the provincial markets and consumers often prefer imported rice over local rice, which are said to be of poor quality as compared to imported ones. That is, only 28% of the respondents in all of the five markets surveyed mentioned that they purchase and sell local rice. Among the five major central provincial markets studied, local rice is very scarce in Kandahar and Hirat markets where no respondent said they do the business of local rice. It was available in Balkh, Jalalabad and Kabul markets where 75%, 40% and 17% of the respondents, respectively, reported that they buy and sell local rice. The Balkh and Jalalabad markets are surrounded by the major rice producing provinces. This may suggest that markets in the surplus and deficit regions are not well–integrated and/or the demand for local rice is rather limited. Figure 1 depicts the structure of rice markets and trade in the country. The imported rice enters into the country through Torkham (Jalalabad), Ghulam Khan (Khost) and Speen Boldak (Kandahar) border customs and moves into the five major central provincial markets, namely, Kabul, Jalalabad, Kandahar, Hirat and Balkh. The imported rice is then sold to the surrounding provinces and on occasions to distant provinces as well. Local rice also follows the same flow but their distribution tends to be concentrated in the nearby markets. Figure 1 also indicates that bidirectional trade flows exist between some of the major rice markets. Trade reversal among the provincial rice markets is also possible (Own survey, 2016).

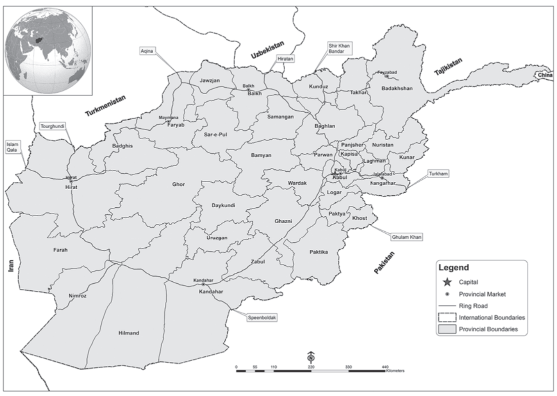

Fig. 2. The domestic rice markets covered in this study.
Source: Author's work

DATA AND METHODS

The data series used in analysis

The data collected and utilized in this research are monthly prices of high and low quality rice, consumer price indices and exchange rates. Annual data on rice production, consumption and imports are also employed in creating the context for readers and supplementing the analysis. The period of study extends from January 2007 to December 2015. Table 1 provides more details about the data series used in this study. We have considered the relationship of domestic markets with those of a supplier country (Pakistan) and the global market. Moreover, 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.[4] 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.[5] The retail prices of Sela and Permal rice in the 7 central provincial markets, namely, Kabul, Jalalabad, Kandahar, Hirat, Balkh, Faizabad and Maimana, are considered as domestic reference prices for high and low quality rice, respectively (Figure 2). The export prices (f.o.b.) of Thai 100% B and Thai 25% broken in Bangkok are used as global reference prices for high and low quality rice, respectively. Pakistan being the major supplier of rice to Afghanistan, its export prices of Basmati and 25% broken rice in Lahore are taken as benchmark for high and low quality rice prices of the supplier country.

Figure 3 and 4 present the pattern of changes in domestic, Pakistani and global prices (real) of high and low quality rice during January 2007 to December 2015.

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[3] A survey of the rice markets was conducted in the major provincial markets, viz., Kabul, Jalalabad, Kandahar, Hirat and Balkh, between April and June 2016. The objective was to collect primary data on the characteristics of rice markets and trade in Afghanistan. A pre–tested semi–structured questionnaire was used and face–to–face interviews were conducted with about 54 rice wholesalers or importers (respondents) in the five markets surveyed.

[4] They showed that Thai 100% B and Thai 5% broken rice prices are cointegrated in the high quality cluster whereas Viet 25%, Thai 25%, Pak 25% and Viet 5% broken rice prices 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.

[5] According to Food and Agriculture Organization of the United Nations (FAO), the rice varieties with less than 20% broken kernels are of high quality whereas those with more than 20% broken kernels are considered low quality.

Table 1. Description of the data series used in this research

Sr. No.	Data Series	Description	Source
1	Sela rice prices (retail)	Monthly retail prices of Sela and Permal rice collected from the central provincial markets of *Kabul, Jalalabad, Kandahar, Hirat, Maimana, Balkh and Faizabad*.	*Market Price Bulletins*, Vulnerability Analysis and Mapping Project, World Food Program, Country Office in Afghanistan
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/* *Thai prices accessed: Mar. 24, 2016* *Pakistani prices accessed: Jan. 16, 2016*
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: Mar. 24, 2016*
8	Exchange Rates (ERs)	Value of US dollar in Afghanis	
9	Miscellaneous	Annual data on rice production, consumption and imports	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* Agriculture Prospects Reports (2005/06 to 2014/15), Ministry of Agriculture, Irrigation and Livestock of Afghanistan

Source: Authors' compilation
Note: The period of study extends from January 2007 to December 2015.

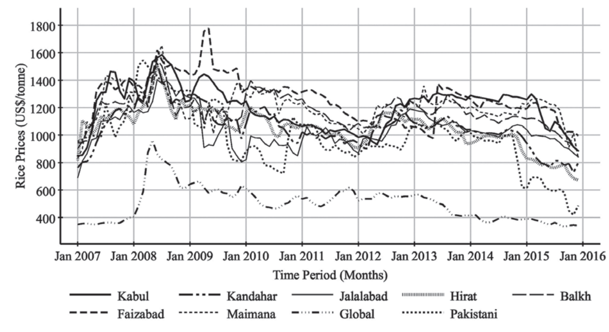

Fig. 3. Trends in domestic (provincial), Pakistani and global prices (real) of high quality rice.
Source: Author's work based on the data collected

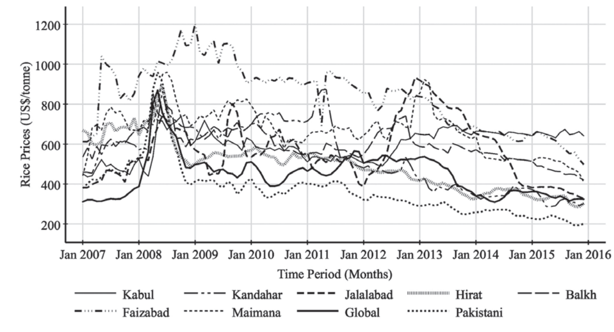

Fig. 4. Trends in domestic (provincial), Pakistani and global prices (real) of low quality rice.
Source: Author's work based on the data collected

It is evident from the Figures that domestic prices of high and low quality rice may follow changes in their respective Pakistani and global markets, more so in the high quality rice market. This may serve as a preliminary indication of cointegration among the high and low quality rice markets. Meanwhile, the price volatility appears to be larger for low than high quality rice prices.

The methods of analysis

First of all, the high and low quality rice prices were tested for unit root using Augmented Dickey–Fuller (1979), Phillips–Perron (1988), Kwiatkowski *et al*. (1992) and Lee–Strazicich (2003) unit root tests. The results suggested that all the price series are integrated of order one or I(1).[6] This property of the price series enables us to examine the existence of a long–run relationship among the pairs of high and low quality rice markets. The Momentum Threshold Autoregressive (M–TAR) model of Enders and Siklos (2001) is adopted in this study to examine the long–run relationship among the pairs of high and low quality rice markets assuming asymmetric adjustment mechanism.[7]

Enders and Siklos (2001) argue that the standard cointegration tests and their extensions are misspecified if adjustment is asymmetric. To account for asymmetry in cointegrating relationship, they extended the

[6] The results of unit root tests are not reported here for a brevity purpose. They can be obtained from the corresponding author upon request.
[7] Although the Engle–Granger (1987) and Johansen (1988) tests of cointegration were also employed in the analysis, the results are not reported here to save space.

Threshold Autoregressive (TAR) and M–TAR models of Enders and Granger (1998) to a multivariate context. TAR model can capture aspects of 'deep movements' whereas M–TAR model captures aspects of 'steep movements' in a price series (Enders and Granger, 1998). The power of M–TAR model is said to be superior to that of TAR and Engle–Granger tests. It is particularly useful if the objective is to smooth out any large change in a series (Enders and Siklos, 2001). Since global and domestic prices of high and low quality rice experienced a dramatic spike in 2007–2008 (Figure 3 and Figure 4), we have applied the consistent M–TAR model to account for this large change in the price series. Equations (1)–(3) below are jointly known as the consistent M–TAR model. In M–TAR model the speed of adjustment towards equilibrium depends on the direction of previous period's change in $\hat{\varepsilon}_{t-1}$, i.e., $\Delta\hat{\varepsilon}_{t-1}$. Accordingly, the speed of adjustment is $\rho_1\hat{\varepsilon}_{t-1}$, if deviations from the long–run equilibrium are positive, and $\rho_2\hat{\varepsilon}_{t-1}$ otherwise.

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

where, I_t is the Heaviside indicator function such that:

$$I_t = \begin{cases} 1 & if\ \ \Delta\hat{\varepsilon}_{t-1} \geq \tau \\ 0 & if\ \ \Delta\hat{\varepsilon}_{t-1} < \tau \end{cases} \qquad (2)$$

where, τ is a consistent threshold value; ρ_1 and ρ_2 denote adjustment coefficients; δ_i shows the coefficients of lagged changes; and ω_t is the i.i.d. disturbance term. The necessary and sufficient conditions for stationarity of $\hat{\varepsilon}_t$ are $\rho_1 < 0$, $\rho_2 < 0$ and $(1+\rho_1)(1+\rho_2)<1$ for any value of τ (Petrucelli and Woolford, 1984). Tong (1983, 1990) showed that the least square estimates of ρ_1 and ρ_2 have an asymptotic multivariate normal distribution provided that $\hat{\varepsilon}_t$ is stationary.

To conduct threshold cointegration test with M–TAR adjustment, the following five–step procedure is adopted. First, a long–run relationship among the pairs of high and low quality rice markets is estimated as follows:

$$P_{1,t} = \alpha_0 + \beta P_{2,t} + \varepsilon_t \qquad (3)$$

where, $P_{1,t}$ and $P_{2,t}$ are logarithms of the real high or low quality rice prices in two spatially separated markets at time t; α_0 is constant term accounting for transaction costs and quality differences; β is the elasticity of price transmission; and ε_t is the disturbance term, which may be serially correlated. Second, the consistent estimates of threshold values for M–TAR models were obtained using Chan (1993) approach. It involves arranging the estimated residuals series, $\hat{\varepsilon}_t$, in ascending order and trimming 15% of both the smallest and the largest observations. The remaining 70% of values are considered as potential thresholds. Equations (1) and (2) are estimated for each of the possible threshold. A super–consistent estimate of threshold, τ, is obtained by minimizing the sum of squared residuals from the fitted model. Third, the long–run relationship among the pairs of high and low quality rice markets is examined by testing the null hypothesis of no cointegration, i.e., $\rho_1 = \rho_2 = 0$, for each of the M–TAR model using the Φ–statistic instead of the F–statistic which has a non–standard distribution. This is equivalent to testing the estimated residuals, $\hat{\varepsilon}_t$, from Equation (3) for non–stationarity. If the null hypothesis of no cointegration is rejected, $\hat{\varepsilon}_t$ is stationary and the pairs of high and low quality rice markets are cointegrated with M–TAR adjustment. Fourth, given that the null hypothesis of no cointegration is rejected, the null hypothesis of no asymmetric adjustment, i.e., $\rho_1 = \rho_2$, is tested for each of the M–TAR model using the standard F–test. Since adjustment is symmetric if $\rho_1 = \rho_2$, Engle–Granger (1987) cointegration test represents a special case of M–TAR model. Fifth, Ljung–Box Q–statistic is used to ensure that the estimated residuals from M–TAR models, $\hat{\omega}_t$, follow a white noise process (Enders and Siklos, 2001).

The Granger representation theorem postulates that an error correction model can best represent cointegrated series (Engle and Granger, 1987). Upon confirmation of cointegration among the pairs of high and low quality rice markets, the dynamics of price transmission among them are analyzed using Asymmetric Vector Error Correction Models (AVECMs) with threshold (M–TAR) adjustment using the Equation below:

$$\Delta P_{1,t} = \mu_0 + \alpha^+ e^+_{t-1} + \alpha^- e^-_{t-1} + \sum_{i=1}^{p-1}\gamma_i\Delta P_{1,t-i} + \sum_{i=1}^{p-1}\theta_i\Delta P_{2,t-i} + \upsilon_t \qquad (4)$$

where, $\Delta P_{1,t}$ is the first difference of logarithms of the real high or low quality rice prices at time t; $P_{1,t}$ and $P_{2,t}$ are the same as in Equation (3); α^+ and α^- denote the speed of adjustment to positive and negative divergences from the long–run equilibrium; the positive and negative error correction terms are defined as $\alpha^+ e^+_{t-1} = I_t\rho_1\hat{\varepsilon}_{t-1}$ and $\alpha^- e^-_{t-1} = (1-I_t)\rho_2\hat{\varepsilon}_{t-1}$, where, I_t has the same definition as in Equation (2); γ_i and θ_i are short–run adjustment coefficients; and υ_t is the i.i.d. disturbance term. The null hypothesis of no short–run asymmetric adjustment, i.e., $\alpha^+ = \alpha^-$, and Granger causality are examined using the standard F–test.

Since the equilibrium adjustment is not asymmetric for all the pairs of high and low quality rice markets (Tables 2–7, Symmetric Vector Error Correction Models (SVECMs) are also estimated as follows:

$$\Delta P_{1,t} = \mu_0 + \alpha e_{t-1} + \sum_{i=1}^{p-1}\gamma_i\Delta P_{1,t-i} + \sum_{i=1}^{p-1}\theta_i\Delta P_{2,t-i} + \upsilon_t \qquad (5)$$

where, $\Delta P_{1,t}$, $P_{1,t}$, $P_{2,t}$, γ_i, θ_i and υ_t are the same as in Equation (4); and αe_{t-1} is the error correction term. The orthogonalized impulse response functions are estimated for each of the SVECM to trace the effects of a unit shock in the principal high and low quality rice markets on that of other markets. The appropriate lag order for unit root tests, M–TAR models, AVECMs and SVECMs is selected using Akaike and Bayesian information criteria (hereinafter AIC and BIC) and ensuring that the residuals are not serially correlated using Ljung–Box Q–statistic at 4, 8 and 12 lags. It is mentionable that the data analysis for this study is carried out in R using its relevant packages, e.g., apt and tsDyn (R Core Team, 2016).

RESULTS AND DISCUSSION

Threshold cointegration among the pairs of high and low quality rice markets

The unit root tests showed that all of the high and low quality rice price series are integrated of order one or I(1), which is a precondition for performing cointegration tests. Hence, the long–run relationship among the pairs of high and low quality rice prices (markets) is examined using the consistent M–TAR models and the results are reported below.

Threshold cointegration between the pairs of provincial and Kabul rice markets

Kabul, the capital city of Afghanistan, is considered as the principal market in this study. Jalalabad, Kandahar, Hirat and Balkh are the major central provincial markets whereas Faizabad and Maimana may be considered as relatively small central provincial markets. Threshold cointegration among the high and low quality rice markets is examined between the central provincial and Kabul rice markets. The results are reported in Table 2. The null hypothesis of no threshold cointegration, i.e., $\rho_1 = \rho_2 = 0$, is rejected at less than the 5% level of significance for all of the pairs of high quality rice markets except for Hirat–Kabul markets pair. However, the latter markets pair is cointegrated under Johansen's cointegration test. Regarding the low quality rice markets pairs, the null hypothesis of no threshold cointegration is rejected only for three of them, i.e., Jalalabad–Kabul, Balkh–Kabul and Faizabad–Kabul. Among the remaining low quality rice markets pairs, only Hirat is reported to be cointegrated with that of Kabul by Johansen's cointegrationt test. That is, Kandahar and Maimana markets of low quality rice may not be cointegrated with the principal market of Kabul. This may suggest that the provincial markets of high quality rice may be better cointegrated with Kabul market of high quality rice as compared to that of low quality rice, which may be due to the increased share of high quality rice in inter–provincial trade.

Since the pairs of high and low quality rice markets are cointegrated, it is possible to test the null hypothesis of no asymmetry in the long–run, i.e., $\rho_1 = \rho_2$, using the standard F–test (Enders and Granger,1998). While the null hypothesis of no long–run asymmetric adjustment is rejected at less than the 10% level of significance for Jalalabad–Kabul, Balkh–Kabul, Faizabad–Kabul and Maimana–Kabul markets pairs in the high quality rice category, it is rejected only for Jalalabad–Kabul and Balkh–Kabul markets pairs in the low quality rice category. This indicates that asymmetric adjustment is prevalent in the high quality rice markets as compared to those of low quality rice in the country. Higher transaction costs, influence of big traders and information asymmetry may be responsible for asymmetric price transmission in the context of Afghanistan (Table 2).

The coefficients of adjustment to positive (ρ_1) and negative (ρ_2) divergences from the long–run equilibrium carry the expected signs (negative) necessary for convergence. Among the high quality rice markets, Jalalabad, Kandahar and Maimana adjust to positive deviations from their long–run equilibrium with the principal market of Kabul such that about 35%, 16% and 21% of positive deviations from the long–run equilibrium are corrected each month, respectively. But, Balkh, Faizabad and Maimana markets adjust to negative deviations from their long–run equilibrium with the principal market of Kabul such that about 30%, 48% and 50% of any divergence from the long–run equilibrium is removed each month, respectively. However, the high quality rice market of Hirat may be weakly exogenous with respect to that of Kabul. This pattern of adjustment may be explained by the structure of rice markets in the country. Since Kandahar and Jalalabad can supply rice to Kabul rice market, they may respond to price increases in Kabul rice market. On the contrary, rice supplies can be channeled from Kabul rice market to that of Balkh, Faizabad and Maimana. Thus, they may respond to price decreases in Kabul rice market (Table 2).

Among the low quality rice markets, Jalalabad, and Faizabad markets adjust to positive deviations from the long–run Jalalabad–Kabul and Faizabad–Kabul equilibrium with the speed of adjustment of about 19% and 13% per month, respectively. The Balkh market of low quality rice adjusts to negative divergences from the long–run Balkh–Kabul equilibrium such that about 25% of any negative deviation is corrected each month, respectively.[8] As in case of high quality rice markets, the low quality rice market of Hirat does not respond to any deviation from the long–run Hirat–Kabul equilibrium. That is, it may be weakly exogenous with respect to Kabul rice market as it independently imports rice from Pakistan or in some cases purchases rice from Kandahar. Comparing the speed of adjustment coefficients between high and low quality rice markets, they are larger for high than low quality rice in the majority of markets pairs. This may indicate the existence of efficient spatial arbitrage in the high quality rice markets (Table 2).

Threshold cointegration between the pairs of domestic and Pakistani rice markets

Since Pakistan has been the major exporter of rice to Afghanistan, it may have greater influence on domestic rice markets. Thus, understanding the dynamics of

[8] Although the coefficients of long–run adjustment are significant for Kandahar and Maimana markets of low quality rice, it is difficult to interpret them as both of them are not cointegrated with the principal market of Kabul. This lack of cointegration renders it impossible to run AVECMs and VECMs for these two markets pairs. Thus, the results of asymmetric and symmetric error correction models are not reported for them.

Table 2. Threshold cointegration (TCI) between the pairs of provincial and Kabul rice markets

Markets Pairs	Lag	ρ_1	ρ_2	τ	Hypothesis Test: Φ–Statistic ($\rho_1 = \rho_2 = 0$)	Hypothesis Test: F–Statistic ($\rho_1 = \rho_2$)
TCI among the pairs of high quality rice markets						
Jalalabad–Kabul	0	–0.345*** (0.000)	–0.048 (0.650)	–0.02 [0.34]	10.091*** (0.000)	5.152** (0.025)
Kandahar–Kabul	0	–0.163*** (0.009)	–0.076 (0.329)	–0.006 [0.263]	3.984** (0.022)	0.778 (0.380)
Hirat–Kabul	2	–0.089 (0.145)	–0.031 (0.527)	0.002 [0.220]	1.228 (0.297)	0.598 (0.441)
Balkh–Kabul	0	–0.087 (0.117)	–0.298*** (0.011)	–0.028 [0.160]	4.560*** (0.013)	2.723* (0.102)
Faizabad–Kabul	2	–0.025 (0.674)	–0.479*** (0.000)	–0.037 [0.246]	9.852*** (0.000)	14.294*** (0.000)
Maimana–Kabul	0	–0.211** (0.023)	–0.498*** (0.000)	–0.020 [0.344]	10.807*** (0.000)	3.483* (0.065)
TCI among the pairs of low quality rice markets						
Jalalabad–Kabul	5	–0.186** (0.034)	-0.029 (0.410)	0.037 [0.604]	2.376* (0.098)	3.310* (0.072)
Kandahar–Kabul	1	–0.070* (0.061)	-0.013 (0.751)	-0.005 [0.724]	1.846 (0.163)	1.055 (0.307)
Hirat–Kabul	3	–0.069 (0.300)	-0.040 (0.358)	0.031 [0.581]	0.992 (0.374)	0.128 (0.722)
Balkh–Kabul	2	–0.023 (0.614)	-0.252** (0.033)	-0.036 [0.288]	2.484* (0.089)	3.306* (0.072)
Faizabad–Kabul	1	–0.133** (0.031)	-0.009 (0.860)	0.003 [0.601]	2.411* (0.095)	2.514 (0.116)
Maimana–Kabul	0	–0.018 (0.653)	-0.180* (0.056)	-0.040 [0.378]	1.962 (0.146)	2.533 (0.115)

Source: Authors' estimation results
Notes: ***, ** and * indicate the 1%, 5% and 10% levels of significance, respectively. The figures in brackets and parenthesis are the minimum residuals at which the threshold value (τ) is selected and the p–values, respectively; and ρ_1 and ρ_2 denote positive and negative long–run adjustment coefficients, respectively. The lag order is selected based on AIC ensuring that there is no autocorrelation and the model is best fit.

long–run relationship between Pakistani and domestic rice markets is very important. Table 3 summarizes the results of threshold cointegration among domestic (provincial) and Pakistani markets of high and low quality rice. The null hypothesis of no threshold cointegration, i.e., $\rho_1 = \rho_2 = 0$, is rejected at the 1% level of significance for all of the Domestic–Pakistani pairs of high and low quality rice markets. This indicates that there may exist a long–run equilibrium relationship among domestic and Pakistani markets of high and low quality rice. It seems that domestic rice markets are following changes in Pakistani rice markets better than changes in the principal rice market of Kabul. It was observed during our field survey of the rice markets that Afghan traders/wholesalers adjust their prices according to changes in the Pakistani rice prices (Own survey, 2016). Hassanzoy *et al.* (2015, 2016) also found that domestic markets of high and low quality rice are cointegrated with their corresponding Pakistani markets.

The null hypothesis of no asymmetry in the long–run, i.e., $\rho_1 = \rho_2$, is rejected at less than the 5% level of significance for most of the Domestic–Pakistani markets pairs of high and low quality rice. That is, except Hirat and Balkh markets in the high and Kabul in the low quality segment, the remaining rice markets may be adjusting asymmetrically to deviations from the long–run equilibrium. The existence of asymmetric adjustment connotes that market imperfections may be present in the rice trade between the two countries (Table 3).

The coefficients of adjustment to positive (ρ_1) and negative (ρ_2) divergences from the long–run equilibrium carry the expected signs (negative) necessary for convergence. All of the provincial markets of high and low quality rice adjust to either positive or negative or both deviations from the long–run equilibrium. Kabul, Jalalabad, Hirat and Balkh markets of high quality rice adjust to positive deviations from their long–run equilibrium with Pakistani markets of high quality rice at the rate of 30%, 32%, 22% and 16% per month, respectively. Kabul, Kandahar, Hirat and Balkh markets of high quality rice respond to negative divergences from their long–run equilibrium with Pakistani markets of high quality rice such that about 11%, 34%, 40% and 33% of a unit negative deviation from the long–run equilibrium is corrected each month, respectively (Table 3).

Among the low quality rice markets, Kabul, Hirat and Balkh adjust to any positive divergence from the long–run Kabul–Pakistani, Hirat–Pakistani and Balkh–

Table 3. Threshold cointegration (TCI) between the pairs of domestic (provincial) and Pakistani rice markets

Markets Pairs	Lag	ρ_1	ρ_2	τ	Hypothesis Test: Φ–Statistic ($\rho_1 = \rho_2 = 0$)	Hypothesis Test: F–Statistic ($\rho_1 = \rho_2$)
TCI among the pairs of high quality rice markets						
Kabul–Pakistani	2	–0.303*** (0.000)	–0.113** (0.033)	0.029 [0.220]	8.682*** (0.000)	3.922** (0.050)
Jalalabad–Pakistani	0	–0.322*** (0.000)	0.180 (0.165)	–0.040 [0.317]	15.073*** (0.000)	12.409*** (0.001)
Kandahar–Pakistani	0	–0.104 (0.181)	–0.339*** (0.000)	0.022 [0.292]	10.695*** (0.000)	4.662** (0.033)
Hirat–Pakistani	1	–0.215*** (0.004)	–0.403 *** (0.003)	–0.040 [0.240]	8.527*** (0.000)	1.569 (0.213)
Balkh–Pakistani	0	–0.155** (0.015)	–0.334*** (0.003)	–0.024 [0.199]	7.594*** (0.001)	1.969 (0.164)
TCI among the pairs of low quality rice markets						
Kabul–Pakistani	2	–0.137*** (0.007)	–0.066 (0.415)	–0.025 [0.276]	4.168** (0.018)	0.552 (0.459)
Jalalabad–Pakistani	5	–0.038 (0.234)	–0.281*** (0.001)	–0.038 [0.504]	6.463*** (0.002)	8.571*** (0.004)
Kandahar–Pakistani	1	0.022 (0.701)	–0.181*** (0.000)	0.008 [0.565]	6.865*** 0.002)	7.496*** (0.007)
Hirat–Pakistani	2	–0.304*** (0.001)	–0.077 (0.291)	0.017 [0.235]	5.893*** (0.004)	3.955** (0.049)
Balkh–Pakistani	0	–0.106* (0.070)	–0.512*** (0.001)	–0.038 [0.250]	7.467*** (0.001)	6.340** (0.013)

Source: Authors' estimation results
Notes: ***, ** and * indicate the 1%, 5% and 10% levels of significance, respectively. The figures in brackets and parenthesis are the minimum residuals at which the threshold value (τ) is selected and the p–values, respectively; and ρ_1 and ρ_2 denote positive and negative long–run adjustment coefficients, respectively. The lag order is selected based on AIC ensuring that there is no autocorrelation and the model is best fit.

Pakistani equilibrium at the rate of about 14%, 30% and 11% each month, respectively. Jalalabad, Kandahar and Balkh markets of low quality rice react to any negative deviation from their long–run equilibrium with those of Pakistani markets such that about 28%, 18% and 51% of a unit negative divergence is removed each month, respectively. It should be noted that the speed of adjustment is faster for high than low quality rice markets for majority of the provincial markets (Table 3). Similar results were reported by Hassanzoy *et al.* (2016) for domestic markets of high and low quality rice with respect to their corresponding Pakistani markets.

Threshold cointegration between the pairs of domestic and global rice markets

As a net rice importing country, Afghanistan depends (directly or indirectly) on the global rice market for meeting its requirements of domestic rice consumption. Table 4 reports the results of threshold cointegration among domestic (provincial) and global markets of high and low quality rice. The null hypothesis of no threshold cointegration among the provincial and global markets of high and low quality rice, i.e., $\rho_1 = \rho_2 = 0$, is rejected at less than the 1% level of significance for all of the high and low quality rice markets pairs, except for the low quality rice markets pair of Hirat–Global. Although the null hypothesis of no threshold cointegration between Hirat and global markets of low quality rice is not significant at the 10% level of significance, it can be significant if we raise the level of significance to less than 12%. However, the presence of cointegration between Hirat–Global markets pair of low quality rice is confirmed by Johansen's cointegration test at the 5% level of significance. Thus, there is a long–run equilibrium relationship among all the provincial and global markets of high and low quality rice. Cointegration among domestic and global markets of high and low quality rice is supported by Hassanzoy *et al.* (2015, 2016).

The null hypothesis of no long–run asymmetry, i.e., $\rho_1 = \rho_2$, is rejected at less than the 10% level of significance for all the pairs of provincial and global markets of low quality rice except for that of Balkh–Global markets pair whereas it is rejected only for Kabul–Global and Kandahar–Global markets pairs of high quality rice (Table 4). This indicates that long–run asymmetry is more prevalent in the domestic markets of low quality rice than those of high quality rice. This is comparable to the adjustment dynamics of the provincial markets with respect to their Pakistani counterparts as discussed in the preceding section. Similar factors responsible for asymmetric adjustment may be at work in the process of adjustment of the provincial rice markets to their respective global and Pakistani markets (Table 4).

The coefficients of adjustment to positive (ρ_1) and

Table 4. Threshold cointegration (TCI) between the pairs of domestic (provincial) and global rice markets

Markets Pairs	Lag	ρ_1	ρ_2	τ	Hypothesis Test: Φ–Statistic ($\rho_1=\rho_2=0$)	Hypothesis Test: F–Statistic ($\rho_1=\rho_2$)
TCI among the pairs of high quality rice markets						
Kabul–Global	2	–0.203*** (0.002)	–0.031 (0.409)	0.023 [0.170]	5.434*** (0.006)	5.580** (0.020)
Jalalabad–Global	4	–0.265** (0.021)	–0.099 (0.113)	0.024 [0.322]	3.563** (0.032)	1.866 (0.175)
Kandahar–Global	0	0.043 (0.622)	–0.165** (0.002)	0.024 [0.245]	5.376*** (0.006)	4.252** (0.042)
Hirat–Global	0	–0.120** (0.017)	0.049 (0.589)	–0.048 [0.224]	3.074** (0.050)	2.665 (0.106)
Balkh–Global	4	–0.112 (0.107)	–0.301** (0.021)	–0.039 [0.196]	3.572** (0.032)	1.947 (0.166)
TCI among the pairs of low quality rice markets						
Kabul–Global	2	–0.043 (0.292)	–0.239*** (0.002)	–0.036 [0.250]	5.452*** (0.006)	5.399** (0.022)
Jalalabad–Global	1	–0.078** (0.035)	–0.275*** (0.007)	–0.071 [0.631]	5.908*** (0.004)	3.554* (0.062)
Kandahar–Global	0	0.050 (0.281)	–0.073** (0.025)	0.028 [0.572]	3.164** (0.046)	4.771** (0.031)
Hirat–Global	2	–0.101** (0.043)	–0.010 (0.659)	0.034 [0.248]	2.207 (0.115)	2.724* (0.102)
Balkh–Global	0	–0.197*** (0.005)	–0.038 (0.605)	–0.006 [0.263]	4.176** (0.018)	2.473 (0.119)

Source: Authors' estimation results
Notes: ***, ** and * indicate the 1%, 5% and 10% levels of significance, respectively. The figures in brackets and parenthesis are the minimum residuals at which the threshold value (τ) is selected and the p–values, respectively; and ρ_1 and ρ_2 denote positive and negative long–run adjustment coefficients, respectively. The lag order is selected based on AIC ensuring that there is no autocorrelation and the model is best fit.

negative (ρ_2) divergences from the long–run equilibrium carry the expected signs (negative) necessary for convergence. Among the high quality rice markets, Kabul, Jalalabad and Hirat markets adjust to any positive deviation from their long–run equilibrium with global rice market at the rate of about 20%, 27% and 12% per month, respectively. But, the high quality rice markets of Kandahar and Balkh react to every negative deviation from the long–run Kandahar–Global and Balkh–Global equilibrium such that about 17% and 30% of any negative deviation is corrected each month, respectively. As regards the low quality rice markets, Jalalabad, Hirat and Balkh adjust to positive deviations from their long–run equilibrium with global market such that about 8%, 10% and 20% of any positive deviation is removed each month, respectively. The low quality rice markets of Kabul, Jalalabad and Kandahar respond to negative deviations from their long–run equilibrium with the respective global market such that about 24%, 28% and 7% of every negative divergence is corrected each month, respectively (Table 4). Again, the adjustment is often faster for high quality rice markets as compared to low quality rice markets.

Asymmetric price transmission (APT) among high and low quality rice markets

APT between the pairs of provincial and Kabul rice markets

The results of asymmetric price transmission among the pairs of provincial and Kabul markets of high and low quality rice markets are presented in Table 5. It can be observed from the Table that the positive and negative error correction coefficients have the expected signs (negative) for convergence toward the long–run equilibrium. Among the provincial markets of high quality rice, Jalalabad adjusts to positive divergence from the long–run Jalalabad–Kabul equilibrium such that about 24% of any positive deviation is corrected every month whereas Balkh, Faizabad and Maimana adjust to negative divergences from their long–run equilibrium with the principal market of Kabul such that about 33%, 50% and 46% of any negative deviation is eliminated each month, respectively. That is, it takes about 2 months to correct 50% of any negative divergence from the long–run equilibrium.

The Table also indicates that the low quality rice markets of Jalalabad and Faizabad adjust to positive divergences from the long–run Jalalabad–Kabul and Faizabad–Kabul equilibrium such that about 21% and 13% of any positive divergence is corrected each month, respectively. This is in contrast to the low quality rice market of Balkh that adjusts to negative deviations from its long–run equilibrium with Kabul low quality rice market such that about 24% of any negative divergence is eliminated each month. It should be noted that the high and low quality rice markets of Hirat along with the high quality rice market of Kandahar may be weakly exogenous with respect to that of Kabul rice market, however. Since Kandahar and Hirat directly import rice from Pakistan, they are not connected much with Kabul rice market. If we compare the speed of adjustment coefficients between high and low quality rice markets, they are larger for high than low quality rice markets. This is supported by Hassanzoy *et al*. (2015, 2016).

The null hypothesis of no short–run asymmetry, i.e., $\alpha^{+}=\alpha^{-}$, is rejected for Faizabad and Maimana markets of high quality rice as well as Jalalabad and Faizabad markets of low quality rice at less than the 10% level of significance. This suggests that the majority of the provincial markets adjust symmetrically to positive and negative divergences from the long–run equilibrium in the short–run. The null hypothesis that Kabul Granger causes the provincial rice markets is rejected only for Faizabad and Maimana markets of high quality rice and Hirat market of low quality rice. However, the significance of either positive or negative error correction coefficient for some of the markets pairs suggests the presence of causality between Kabul and the provincial rice markets. Although the null hypothesis of Granger causality may be rejected for the low quality rice market of Hirat, it is not supported by the error correction coefficients (Table 5).

APT between the pairs of domestic and Pakistani rice markets

Table 6 summarizes the results of asymmetric price transmission among domestic (provincial) and Pakistani markets of high and low quality rice. The short–run coefficients of speed of adjustment have the expected signs (negative) for convergence towards the long–run equilibrium. Among the high quality rice markets, Kabul, Jalalabad, Kandahar and Balkh adjust to positive deviations from their long–run equilibrium with Pakistani market of high quality rice such that about 32%, 28%, 22% and 14% of any positive deviation is eliminated each month, respectively. That is, it takes 3 to 5 months to remove 50% of a unit positive deviation from the long–run equilibrium. The high quality rice markets of Kabul, Kandahar, Hirat and Balkh adjust to negative deviations from their long–run equilibrium with Pakistani market of high quality rice such that about 11%, 22%, 32% and 35% of a unit negative deviation is corrected each month, respectively. This suggests that 2 to 7 months are needed to remove 50% of a unit negative divergence from the long–run equilibrium.

As regards the low quality provincial rice markets, Jalalabad, Kandahar and Balkh adjust to negative divergences from the long–run Jalalabad–Pakistani, Kandahar–Pakistan and Balkh–Pakistani equilibrium such that

Table 5. Asymmetric price transmission (APT) between the pairs of provincial and Kabul rice markets

Markets Pairs	Lag	α^{+}	HL	α^{-}	HL	Hypothesis Test	
						AS–Test ($\alpha^{+}=\alpha^{-}$)	GC–Test
APT among the pairs of high quality rice markets							
Jalalabad–Kabul	3	–0.236*** (0.005)	3	–0.092 (0.453)	8	1.151 (0.286)	1.664 (0.180)
Kandahar–Kabul	2	–0.086 (0.171)	8	–0.078 (0.293)	9	0.008 (0.930)	2.275 (0.108)
Hirat–Kabul	2	–0.038 (0.548)	19	0.012 (0.807)	57	0.438 (0.510)	1.954 (0.147)
Balkh–Kabul	2	–0.105 (0.111)	7	–0.328** (0.023)	2	2.203 (0.141)	1.462 (0.237)
Faizabad–Kabul	2	–0.039 (0.527)	18	–0.498*** (0.000)	2	13.083 *** (0.000)	2.321* (0.104)
Maimana–Kabul	2	–0.106 (0.308)	7	–0.461*** (0.001)	2	5.180** (0.025)	2.697* (0.072)
APT among the pairs of low quality rice markets							
Jalalabad–Kabul	3	–0.207** (0.033)	4	–0.021 (0.565)	33	3.582* (0.061)	1.599 (0.195)
Hirat–Kabul	3	–0.066 (0.114)	11	–0.018 (0.486)	39	0.932 (0.337)	6.336*** (0.001)
Balkh–Kabul	2	–0.031 (0.493)	23	–0.236** (0.049)	3	2.626 (0.108)	1.357 (0.262)
Faizabad–Kabul	3	–0.128** (0.048)	6	0.016 (0.770)	43	2.925* (0.090)	1.494 (0.221)

Source: Authors' estimation results
Notes: ***, ** and * indicate the 1%, 5% and 10% levels of significance, respectively. α^{+} and α^{-} are positive and negative error correction coefficients, respectively; HL: Half Life indicates the time required to eliminate 50% of positive or negative deviations from the long-run equilibrium; and figures in brackets are the p-values. The lag order is selected by AIC and BIC criteria ensuring that there is no autocorrelation and the model is best fit. GC: Granter causality; AS-test: asymmetry test.

about 22%, 17% and 46% of a unit negative deviation from the long–run equilibrium is removed each month, respectively. But, none of the provincial markets respond to positive deviations from their long–run equilibrium with Pakistani market of low quality rice in the short–run. Kabul and Hirat markets of low quality rice may be weakly exogenous with respect to that of Pakistani market, however. The time required to remove 50% of a unit negative deviation from the long–run equilibrium ranges from 2 to 4 months. It is observed that the adjustment coefficients are larger for high than low quality rice markets in the majority of the markets pairs (Table 6). Hassanzoy *et al*. (2015, 2016) reported similar results.

The null hypothesis of no short–run asymmetry is rejected at less than the 10% level of significance for most of the high and low quality rice markets. That is, the high quality rice markets of Kabul, Jalalabad, Hirat and Balkh and the low quality rice markets of Jalalabad, Kandahar and Balkh adjust asymmetrically to any divergence from the long–run equilibrium with the corresponding Pakistani rice markets. This is suggestive of the presence of some kind of market imperfections. As regards Granger causality, the F–test failed to rejected the null hypothesis that Pakistani market of high quality rice do not Granger cause domestic markets of high quality rice whereas Pakistani market of low quality rice Granger causes Balkh, Hirat and Kabul markets of low quality rice. The significance of the speed of adjustment coefficients for all of the provincial markets of high quality rice as well as Jalalabad and Kandahar markets of low quality rice along with the weakly exogenous status of the low quality rice markets of Kabul and Hirat do not support the results of Granger causality (Table 6).

APT between the pairs of domestic and global rice markets

The results of asymmetric price transmission among domestic (provincial) and global markets of high and low quality rice are presented in Table 7. The Table shows that the positive and negative error correction coefficients carry the expected signs (negative) for ensuring convergence towards the long–run equilibrium. Among the provincial markets of high quality rice, Kabul, Jalalabad, Hirat and Balkh adjust to positive divergence from their long–run equilibrium with global market of high quality rice such that about 24%, 32%, 8% and 15% of a unit positive deviation is decayed each month, respectively. Jalalabad and Kandahar high quality rice markets respond to negative divergences from the long–run Jalalabad–Global and Kandahar–Global equilibrium such that about 10% and 12% of any negative deviation is eliminated each month, respectively.

Table 6. Asymmetric price transmission (APT) between the pairs of domestic (provincial) and Pakistani rice markets

Markets Pairs	Lag	α^+	HL	α^-	HL	Hypothesis Test: AS–Test ($\alpha^+=\alpha^-$)	Hypothesis Test: GC–Test
APT among the pairs of high quality rice markets							
Kabul–Pakistani	2	–0.319*** (0.000)	3	–0.105** (0.019)	7	6.416** (0.013)	1.029 (0.3619)
Jalalabad–Pakistani	3	–0.284*** (0.000)	3	0.152 (0.271)	4	8.485*** (0.004)	1.488 (0.223)
Kandahar–Pakistani	2	–0.220*** (0.003)	3	–0.222*** (0.001)	3	0.001 (0.979)	0.189 (0.828)
Hirat–Pakistani	2	–0.074 (0.258)	10	–0.316*** (0.009)	3	3.580* (0.061)	0.342 (0.711)
Balkh–Pakistani	1	–0.140** (0.026)	5	–0.349*** (0.002)	2	2.763* (0.100)	0.369 (0.545)
APT among the pairs of low quality rice markets							
Kabul–Pakistani	3	–0.015 (0.781)	47	0.037 (0.656)	18	0.303 (0.583)	4.269*** (0.007)
Jalalabad–Pakistani	5	–0.039 (0.248)	18	–0.218** (0.015)	4	3.945** (0.050)	0.826 (0.534)
Kandahar–Pakistani	2	0.053 (0.309)	13	–0.168*** (0.000)	4	11.086*** (0.001)	1.097 (0.338)
Hirat–Pakistani	2	–0.053 (0.509)	13	0.021 (0.738)	33	0.548 (0.461)	18.075*** (0.000)
Balkh–Pakistani	2	–0.080 (0.182)	9	–0.455*** (0.005)	2	4.936** (0.029)	5.068*** (0.008)

Source: Authors' estimation results
Notes: ***, ** and * indicate the 1%, 5% and 10% levels of significance, respectively. α^+ and α^- are positive and negative error correction coefficients, respectively; HL: Half Life indicates the time required to eliminate 50% of positive or negative deviations from the long-run equilibrium; and figures in brackets are the p-values. The lag order is selected by AIC and BIC criteria ensuring that there is no autocorrelation and the model is best fit. GC: Granter causality; AS-test: asymmetry test.

As regards the adjustment dynamics between domestic and global markets of low quality rice, Jalalabad and Hirat react to any positive divergence from the long–run Jalalabad–Global and Hirat–Global equilibrium in a way that about 7% and 13% of a unit positive deviation is removed each month, respectively. Kabul, Jalalabad and Kandahar low quality rice markets adjust to negative deviations from their long–run equilibrium with global market of low quality rice such that about 17%, 21% and 5% of a unit negative deviation is decayed each month, respectively. The Balkh low quality rice market might be weakly exogenous with respect to that of global market but this hypothesis can be rejected at less than 12% level of significance. A comparison of the speed of adjustment coefficients between high and low quality rice markets indicates that they are relatively larger for high than low quality rice markets in majority of the markets pairs (Table 7). This is supported by Hassanzoy *et al.* (2015, 2016).

The null hypothesis of no short–run asymmetric adjustment is rejected for the majority of high and low quality rice markets at the 5% level of significance. That is, Kabul, Jalalabad and Hirat markets of high quality rice may adjust asymmetrically to their long–run equilibrium with the respective global rice market. The short–run asymmetry also holds for Kabul, Kandahar and Hirat markets of low quality rice. This indicates that the provincial rice markets may not be efficient and market imperfections exist. Moreover, the null hypothesis that global high and low quality rice markets do not Granger cause those of domestic markets is rejected at less than the 5% level of significance for all of the high and low quality rice markets pairs except Jalalabad and Balkh low quality rice markets. This may not be true for Jalalabad low quality rice market as both positive and negative error correction coefficients are significant for that market (Table 7).

Symmetric price transmission (SPT) among high and low quality rice markets

It was shown in the previous sections that not all of the domestic markets of high and low quality rice adjust asymmetrically to deviations from the long–run equilibrium. This necessitated fitting symmetric vector error correction models (SVECMs) to the pairs of rice markets. The results of SVECMs are presented below.

SPT between the pairs of provincial and Kabul rice markets

The results of symmetric price transmission among the pairs of provincial and Kabul markets of high and low quality rice are summarized in Table 8. It is evident from

Table 7. Asymmetric price transmission (APT) between the pairs of domestic (provincial) and global rice markets

Markets Pairs	Lag	α^+	HL	α^-	HL	Hypothesis Test: AS–Test ($\alpha^+=\alpha^-$)	Hypothesis Test: GC–Test
APT among the pairs of high quality rice markets							
Kabul–Global	3	–0.243*** (0.001)	3	–0.026 (0.465)	27	7.800*** (0.006)	3.840** (0.012)
Jalalabad–Global	2	–0.322*** (0.002)	2	–0.095* (0.099)	8	4.079** (0.046)	3.242** (0.043)
Kandahar–Global	2	–0.029 (0.745)	24	–0.118** (0.019)	6	0.788 (0.377)	2.977* (0.056)
Hirat–Global	2	–0.077* (0.100)	9	0.103 (0.209)	6	3.955** (0.050)	7.066*** (0.001)
Balkh–Global	2	–0.154** (0.013)	5	–0.204 (0.121)	4	0.126 (0.723)	3.452** (0.036)
APT among the pairs of low quality rice markets							
Kabul–Global	3	0.011 (0.802)	47	–0.171* (0.056)	4	3.844* (0.053)	4.274*** (0.007)
Jalalabad–Global	4	–0.070* (0.078)	18	–0.214** (0.036)	4	1.942 (0.167)	1.544 (0.196)
Kandahar–Global	2	0.057 (0.188)	13	–0.049* (0.102)	14	4.147** (0.044)	4.005** (0.021)
Hirat–Global	2	–0.131*** (0.004)	13	0.014 (0.512)	49	8.749*** (0.004)	9.225*** (0.000)
Balkh–Global	2	–0.129 (0.113)	9	0.049 (0.553)	14	2.327 (0.130)	1.054 (0.353)

Source: Authors' estimation results
Notes: ***, ** and * indicate the 1%, 5% and 10% levels of significance, respectively. α^+ and α^- are positive and negative error correction coefficients, respectively; HL: Half Life indicates the time required to eliminate 50% of positive or negative deviations from the long-run equilibrium; and figures in brackets are the p-values. The lag order is selected by AIC and BIC criteria ensuring that there is no autocorrelation and the model is best fit. GC: Granter causality; AS-test: asymmetry test.

the Table that Jalalabad, Kandahar, Faizabad and Maimana markets of high quality rice adjust to any divergence from their long–run equilibrium with the principal market of Kabul such that about 24%, 8%, 14% and 24% of any deviation is eliminated each month, respectively. The time required to remove 50% of a unit deviation is minimum for Jalalabad high quality rice market, i.e., 3 months. It should be noted that Hirat and Balkh markets of high quality rice may be weakly exogenous with respect to that of Kabul market. This is supported by the results of asymmetric vector error correction model for the pair of Hirat–Kabul markets of high quality rice (Table 5). The extent of price transmission is maximum for Kandahar (79%) and minimum for Balkh (48%) high quality rice markets. This indicates that about 79% and 48% of a change in Kabul high quality rice prices may be transmitted to that of Kandahar and Balkh markets, respectively.

Among the provincial markets of low quality rice, only Hirat adjusts to divergences from the long–run Hirat–Kabul equilibrium such that about 5% of a unit deviation is corrected monthly. The remaining low quality rice markets may be weakly exogenous with respect to that of Kabul market as their speed of adjustment coefficients are not significant at the conventional levels. However, non–linear relationship may exist among these markets as explained under asymmetric price transmission (Table 5). The elasticity of price transmission is maximum for the low quality rice market of Hirat (100%). It should be noted that the speeds of adjustment and elasticities of price transmission are larger for the provincial markets of high than low quality rice in the majority of the rice markets pairs (Table 8).

Table 8. Symmetric price transmission (SPT) between the pairs of provincial and Kabul rice markets

Markets Pairs	SPT among the pairs of high quality rice markets				SPT among the pairs of low quality rice markets			
	Lag	α	HL	β	Lag	α	HL	β
Jalalabad–Kabul	2	–0.241*** (0.001)	3	0.656*** (0.000)	3	–0.038 (0.285)	19	0.674*** (0.000)
Kandahar–Kabul	2	–0.082* (0.092)	9	0.790*** (0.000)	–	–	–	–
Hirat–Kabul	2	–0.007 (0.873)	99	0.600*** (0.000)	2	–0.053** (0.016)	13	–1.043*** (0.000)
Balkh–Kabul	4	–0.085 (0.201)	8	0.476*** (0.000)	2	–0.057 (0.184)	13	–0.122 (0.213)
Faizabad–Kabul	2	–0.139** (0.019)	5	0.612*** (0.000)	2	–0.036 (0.314)	20	–0.045 (0.723)
Maimana–Kabul	2	–0.237*** (0.008)	3	0.510*** (0.000)	–	–	–	–

Source: Authors' estimation results
Notes: ***, ** and * indicate the 1%, 5% and 10% levels of significance, respectively. HL stands for Half Life, which is the time required to eliminate 50% of any deviations from the long–run equilibrium. β and α indicate the elasticity of price transmission and error correction term, respectively. The lag order is selected by AIC and BIC criteria ensuring that there is no autocorrelation and the model is best fit.

Table 9. Symmetric price transmission (SPT) between the pairs of domestic (provincial) and Pakistani rice markets

Markets Pairs	SPT among the pairs of high quality rice markets				SPT among the pairs of low quality rice markets			
	Lag	α	HL	β	Lag	α	HL	β
Kabul–Pakistani	3	–0.161*** (0.000)	5	0.317*** (0.000)	2	–0.017 (0.696)	41	–0.144*** (0.000)
Jalalabad–Pakistani	5	–0.181** (0.012)	4	0.298*** (0.000)	5	–0.055* (0.095)	13	0.169 ** (0.032)
Kandahar–Pakistani	2	–0.221*** (0.000)	3	0.441*** (0.000)	1	–0.074** (0.031)	10	0.781*** (0.000)
Hirat–Pakistani	1	–0.138** (0.016)	5	0.491*** (0.000)	2	–0.007 (0.886)	99	0.762*** (0.000)
Balkh–Pakistani	1	–0.191*** (0.001)	4	0.239*** (0.000)	1	–0.110** (0.052)	7	0.305*** (0.000)

Source: Authors' estimation results
Notes: ***, ** and * indicate the 1%, 5% and 10% levels of significance, respectively. HL stands for Half Life, which is the time required to eliminate 50% of any deviations from the long-run equilibrium. β and α indicate the elasticity of price transmission and error correction term, respectively. The lag order is selected by AIC and BIC criteria ensuring that there is no autocorrelation and the model is best fit.

SPT between the pairs of domestic and Pakistani rice markets

Table 9 reports the results of symmetric price transmission among the pairs of domestic (provincial) and Pakistani high and low quality rice markets. The error correction coefficients have the expected signs (negative) for convergence and are significant at less than the 5% level of significance for all of the pairs of domestic and Pakistani markets of high quality rice. Kabul, Jalalabad, Kandahar, Hirat and Balkh high quality rice markets adjust to any divergence from their long–run equilibrium with that of Pakistani market such that around 16%, 18%, 22%, 14% and 19% of a unit discrepancy is corrected each month, respectively. The time required to correct 50% of any deviation from the long–run equilibrium is minimum for Kandahar (3 months) whereas it is maximum for Hirat (5 months). Moreover, the extent of price transmission ranges from 24% for Balkh to 49% for Hirat market of high quality rice.

Among the domestic markets of low quality rice, Jalalabad, Kandahar and Balkh adjust to any deviation from the long–run Jalalabad–Pakistani, Kandahar–Pakistani and Balkh–Pakistani equilibrium such that about 5%, 7% and 11% of a unit divergence is eliminated each month, respectively. The remaining low quality rice markets (Kabul and Hirat) may be weakly exogenous with respect to that of Pakistani market. This is similar to the findings reported by asymmetric error correction models (Table 6). While it takes 7 months to correct 50% of every divergence from the long–run Balkh–Pakistani equilibrium, about 13 months are needed to decay a similar magnitude of divergence from the long–run Jalalabad–Pakistani equilibrium. The extent of price transmission is minimum for the low quality rice market of Jalalabad (17%) whereas it is maximum for that of Kandahar (78%) market. Although the adjustment coefficients are larger for high than low quality rice markets, the extent of price transmission is larger for the majority of low quality rice markets. Hassanzoy *et al*. (2015, 2016) reported similar results for domestic markets of high and low quality rice (Table 9).

SPT between the pairs of domestic and global rice markets

Table 10 presents the results of symmetric price transmission among domestic (provincial) and global markets of high and low quality rice. Among the domestic markets of high quality rice, Kabul, Jalalabad, Kandahar and Balkh adjust to divergences from their long–run equilibrium with that of global market such that about 7%, 16%, 10% and 16% of any divergence is corrected each month, respectively. The time required to eliminate 50% of a unit deviation from the long–run equilibrium is minimum for Balkh (5 months) whereas it is maximum for Kabul (10 months). It can be observed in the Table that the extent of price transmission ranges from 18% for Kabul market of high quality rice to 41% for that of Kandahar market.

Most of the domestic markets of low quality rice may be weakly exogenous with respect to the global market of low quality rice except for Jalalabad, which adjusts to any deviation from the long–run Jalalabad–Global equilibrium at the speed of 8% per month. That is, it takes about 9 months to correct 50% of a unit divergence from the long–run equilibrium. This result is, however, not supported by asymmetric price transmission (Table 7). The extent of price transmission is maximum for the low quality rice market of Kandahar (71%) whereas it is minimum for that of Balkh (39%). Moreover, the speed of adjustment is faster for domestic markets of high quality rice whereas the extent of price transmission is larger for the majority of the low quality rice markets pairs (Table 10). This is supported by Hassanzoy *et al*. (2015, 2016) who reported similar results for domestic markets of

Table 10. Symmetric price transmission (SPT) between the pairs of domestic (provincial) and global rice markets

Markets Pairs	SPT among the pairs of high quality rice markets				SPT among the pairs of low quality rice markets			
	Lag	α	HL	β	Lag	α	HL	β
Kabul–Global	3	–0.072** (0.030)	10	0.184*** (0.001)	2	–0.043 (0.288)	16	0.066 (0.241)
Jalalabad–Global	1	–0.155*** (0.002)	5	0.208*** (0.000)	4	–0.084** (0.031)	9	0.572*** (0.000)
Kandahar–Global	2	–0.099** (0.028)	7	0.414*** (0.000)	1	–0.010 (0.691)	70	0.710*** (0.000)
Hirat–Global	1	–0.059 (0.149)	5	0.399*** (0.000)	1	–0.023 (0.240)	30	0.497*** (0.000)
Balkh–Global	2	–0.163*** (0.005)	5	0.230*** (0.000)	1	–0.045 (0.411)	16	0.385*** (0.000)

Source: Authors' estimation results
Notes: ***, ** and * indicate the 1%, 5% and 10% levels of significance, respectively. HL stands for Half Life, which is the time required to eliminate 50% of any deviations from the long-run equilibrium. β and α indicate the elasticity of price transmission and error correction term, respectively. The lag order is selected by AIC and BIC criteria ensuring that there is no autocorrelation and the model is best fit.

[9] After increasing effect for the initial 4 months, the effect of a shock in Kabul market of high quality rice on that of Hirat market has declined. This suggests the effect may be temporary.

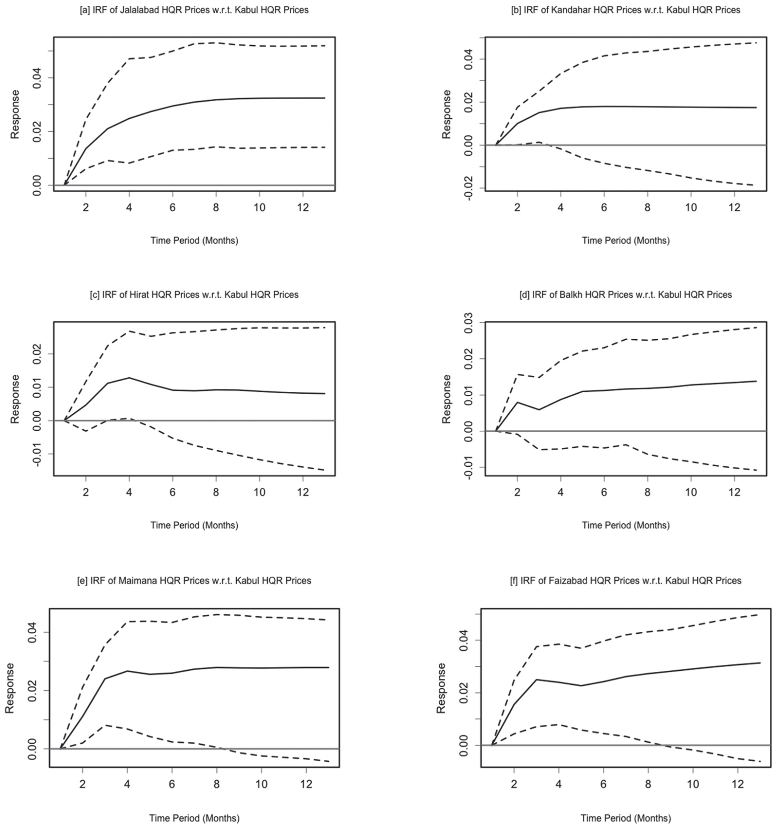

Fig. 5. IRFs of the provincial markets of high quality rice with respect to (w.r.t.) a shock in the respective Kabul market.
Source: Author's estimation results

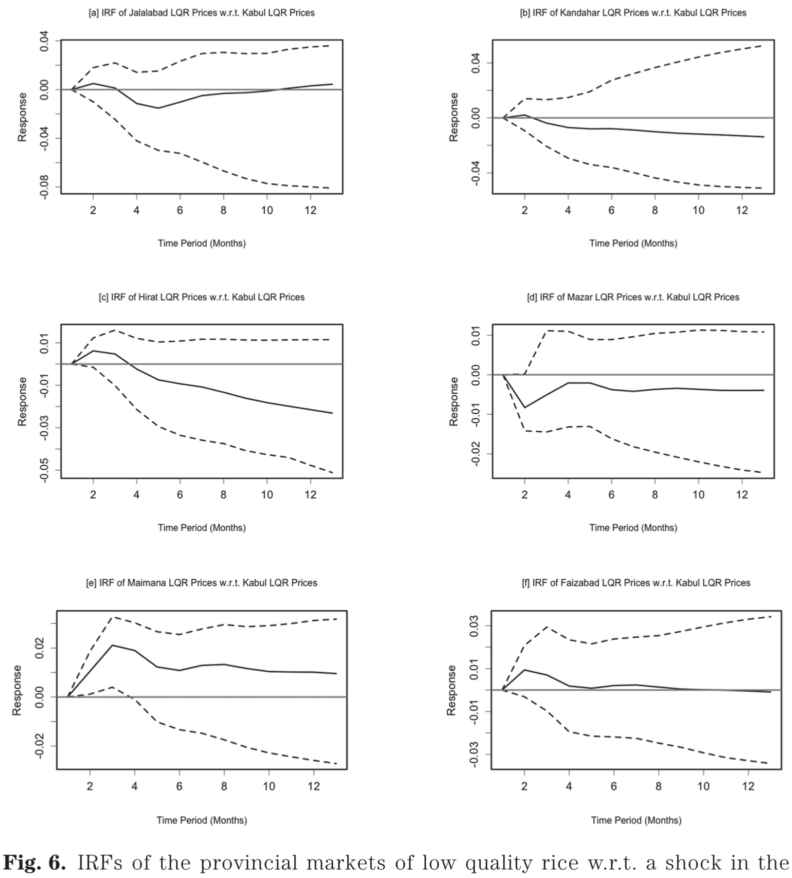

Fig. 6. IRFs of the provincial markets of low quality rice w.r.t. a shock in the respective Kabul market.
Source: Author's estimation results

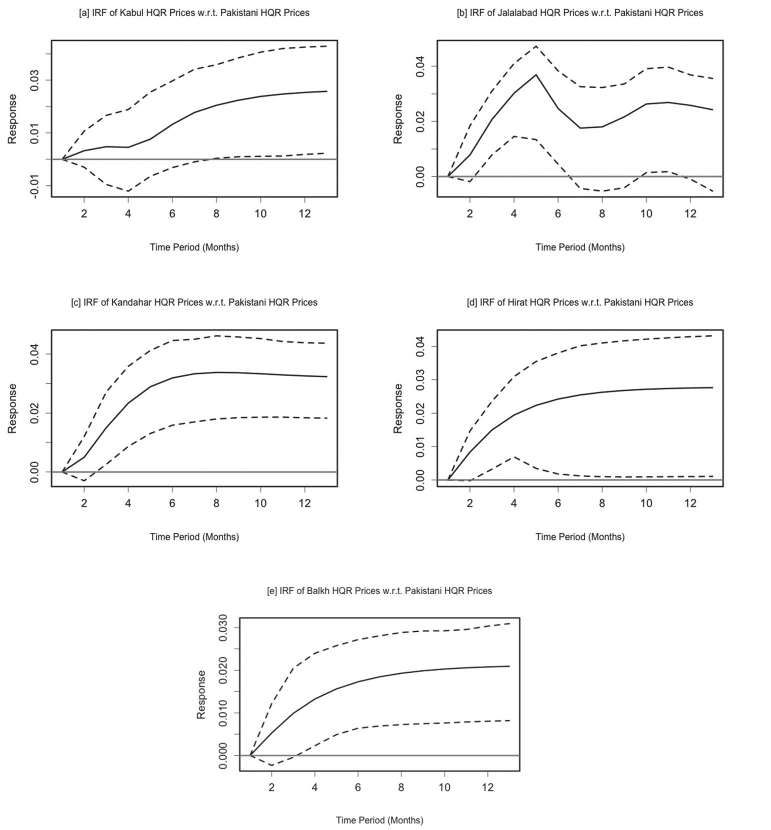

Fig. 7. IRFs of the domestic (provincial) markets of high quality rice w.r.t. a shock in the respective Pakistani market.
Source: Author's estimation results

high and low quality rice.

Impulse response functions for high and low quality rice prices

Panels (a–f) of Figure 5 depict the impulse response functions (IRFs) of the provincial markets of high quality rice with respect to a random shock in that of Kabul market. It is evident from the Figure that a shock in the high quality rice market of Kabul has a rapid positive effect on the corresponding provincial rice markets for the initial few months but the effect is stabilized at a relatively higher level afterward.[9] That is, the effects may be long–lasting.

Panels (a–f) of Figure 6 portray the IRFs of the provincial markets of low quality rice with respect to a random shock in that of Kabul market. It can be observed from the Figure that a shock in Kabul market of low quality rice has a very weak positive effect for the initial few months but the effect turns negative afterwards in case of Jalalabad, Kandahar and Hirat low quality rice markets. The effect is negative for Balkh but positive for Maimana and Faizabad with decreasing trend after the first 2 to 3 months. In short, a shock in Kabul market of high quality rice may have strong effect on the corresponding provincial market as compared to the effect on the provincial markets of low quality rice of a shock in the respective market of Kabul.

Panels (a–e) of Figure 7 show IRFs of domestic markets of high quality rice with respect to a shock in the corresponding Pakistani market. It can be observed from the Figure that a random shock in Pakistani market of high quality rice has positive effect on that of Kabul, Kandahar, Hirat and Balkh markets such that the effect is rapidly increasing for the initial few months but sustained at a higher level afterwards. The response of Jalalabad high quality rice market to a shock in its corresponding Pakistani market traces cyclical response pattern. That is, a shock in Pakistani market of high quality rice has rapidly increasing effect on that of Jalalabad market for the initial 5 months, which is followed by a decrease and increase in turn. This suggests that a random shock in Pakistani market of high quality rice has long–lasting effect on that of Kabul, Kandahar, Hirat and Balkh but the effect may be temporary for that of Jalalabad market.

Panels (a–e) of Figure 8 depict the IRFs of domestic markets of low quality rice with respect to a shock in that of Pakistani market. The Figure shows that a shock in Pakistani market of low quality rice has increasing effect on that of Kabul, Jalalabad and Hirat markets for the first few months but the effect is declined afterwards. This indicates that a shock in Pakistani market of low quality rice may have temporary effect on that of Kabul, Jalalabad and Hirat market. However, a random shock in Pakistani market of low quality rice has increasing effect on the corresponding markets of Kandahar and

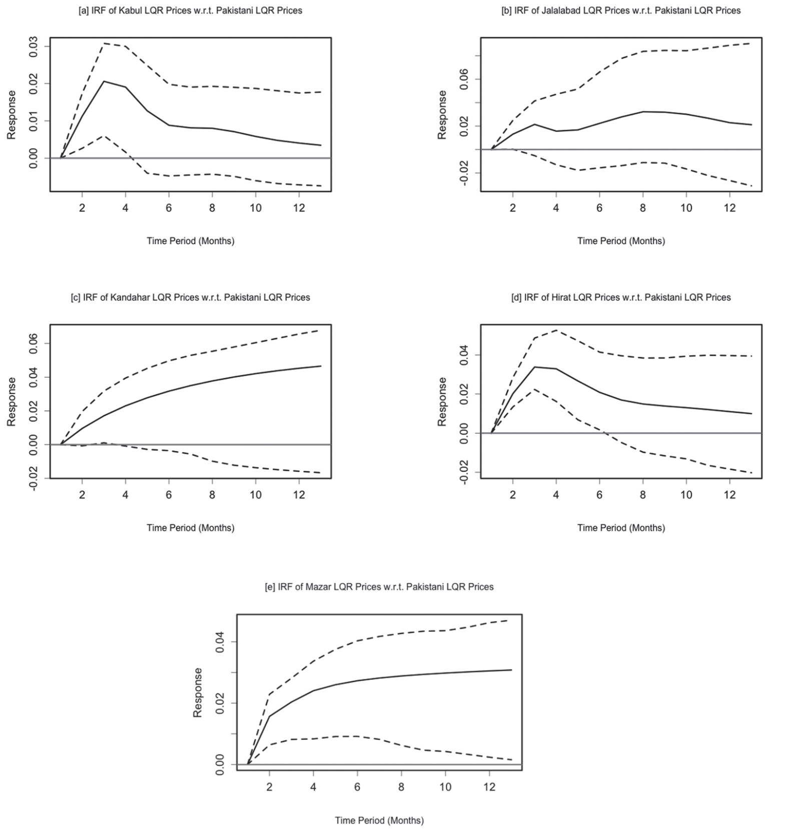

Fig. 8. IRFs of the domestic (provincial) markets of low quality rice w.r.t. a shock in the respective Pakistani market.
Source: Author's estimation results

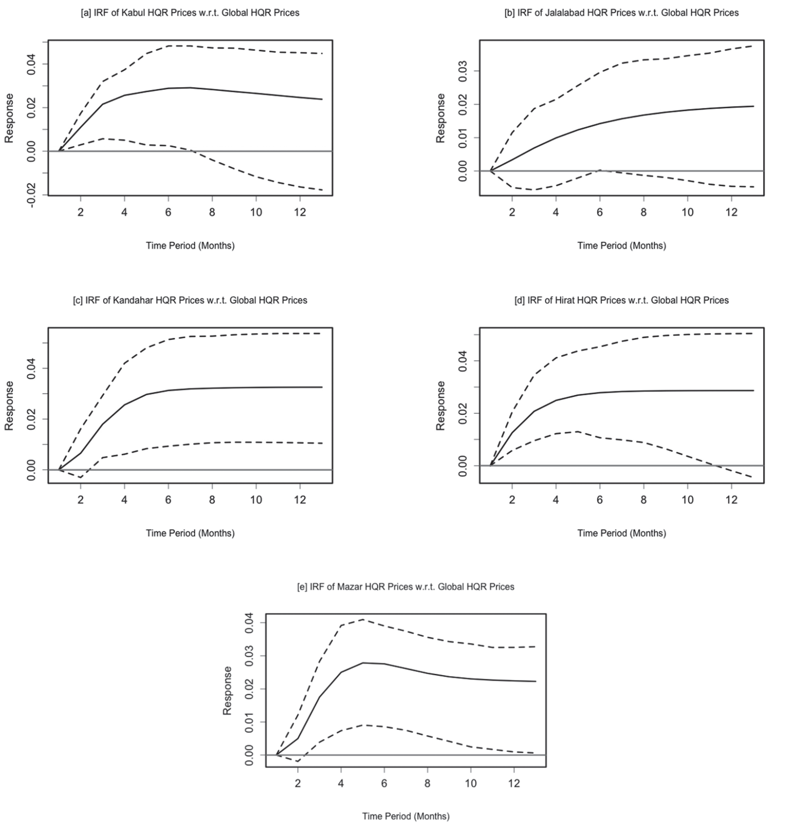

Fig. 9. IRFs of the domestic (provincial) markets of high quality rice w.r.t. a shock in the respective global market.
Source: Author's estimation results

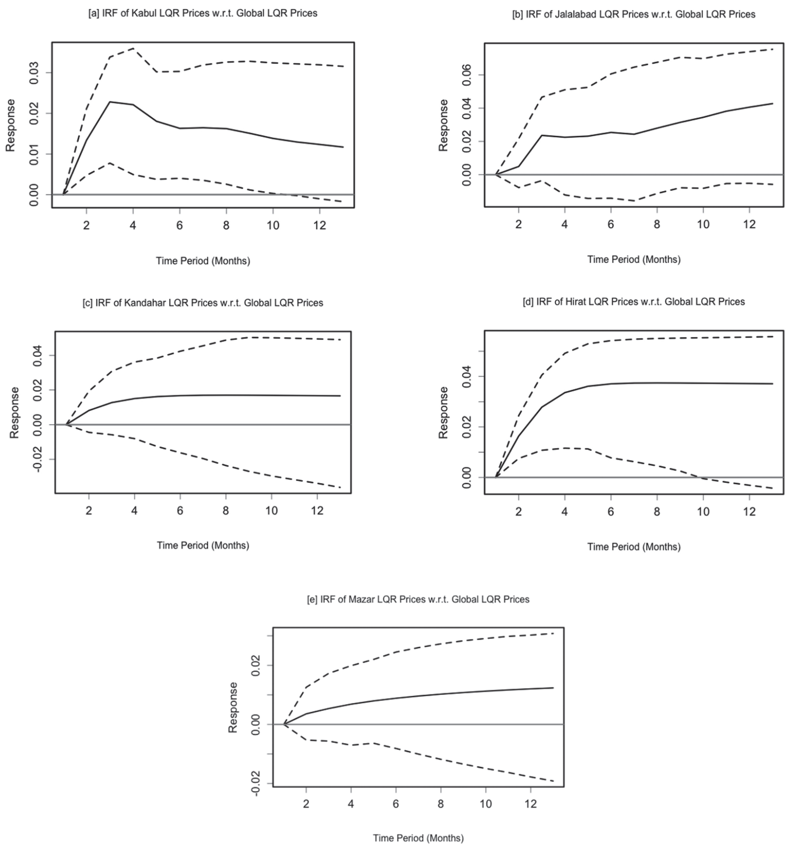

Fig. 10. IRFs of the domestic (provincial) markets of low quality rice w.r.t. a shock in the respective global market.
Source: Author's estimation results

Balkh for the initial few months but it is sustained at a higher level afterwards. That is, the shock may have long–lasting effect on Kandahar and Balkh markets of low quality rice.

Panels (a–e) of Figure 9 depict IRFs of the domestic markets of high quality rice with respect to a random shock in that of Global market. It is evident from the Figure that a one standard deviation unit shock in Global market of high quality rice has an initial rapidly increasing effect on the corresponding domestic markets of Kabul, Jalalabad, Kandahar, Hirat and Balkh but the effect is sustained at a higher level afterwards. This indicates that the effect of a shock in Global market of high quality rice on that of domestic markets may be long–lasting.

Panels (a–e) of Figure 10 portray IRFs of the domestic markets of low quality rice with respect to a random shock in that of global market. It can be observed from the Figure that a shock in global market of low quality rice has an initial increasing effect on domestic markets of Kabul, Jalalabad, Kandahar, Hirat and Balkh but the effect is declined in case of Kabul but sustained for the remaining markets afterwards. That is, the shock may have long–lasting effect on majority of the domestic markets except Kabul for which the effect may be temporary. Overall, the effect of a shock in Kabul, Pakistani and global markets of high and low quality rice is very weak on their corresponding provincial markets.

CONCLUSIONS AND POLICY IMPLICATIONS

Despite the landlocked situation, poor infrastructure, weak marketing and trading institutions, high transportation costs and political instability in the country, the provincial markets of high and low quality rice may have a long–run equilibrium relationship with their corresponding principal market of Kabul, exceptions being Kandahar and Maimana markets of low quality rice. This indicates that the provincial markets of low quality rice do not constitute a single economic market. The major provincial markets of high and low quality rice may also be cointegrated with their respective Pakistani and global markets. Although Pakistan is a single major supplier of rice to Afghanistan, Thailand, usually treated as the global reference market for rice, is not a direct trading partner of the country. This implies that markets may be integrated with or without direct trading relationships.

Evidence of short– and long–run asymmetric adjustment was observed in this study among the domestic markets of high and low quality rice with respect to their

[10] For instance, the high quality rice market of Kandahar is weakly exogenous with respect to Kabul under non–linear adjustment whereas it responds to deviations from the long–run Kandahar–Kabul equilibrium under linear adjustment.

corresponding Kabul, Pakistani and global markets. While the long–run asymmetry is prevalent among the pairs of provincial and Kabul markets of high quality rice (67% vs. 33% of markets pairs), it is dominant among the pairs of provincial and Pakistani (60% vs. 80% of markets pairs) as well as provincial and global markets of low quality rice (40% vs. 80% of markets pairs). The short–run asymmetry is observed equally among the provincial and global markets of high and low quality rice (60% vs. 60% of markets pairs). However, short–run asymmetry is prevalent among the pairs of provincial and Kabul markets of low quality rice (33% vs. 50% of markets pairs) whereas it is dominant among the provincial and Pakistani markets pairs of high quality rice (80% vs. 60% of markets pairs). These findings suggest the existence of temporary and persistent inefficiencies among the high and low quality rice markets in the country. A comparison of the short– and long–run speed of adjustment coefficients among high and low quality rice markets pairs suggests that they are relatively faster for high than low quality rice markets. This implies that the spatial arbitrage may be more efficient and/or remunerative in the high than low quality rice markets.

The adjustment dynamics of high and low quality rice markets may be linear (symmetric) and/or non–linear (asymmetric), which necessitates considering both types of adjustment dynamics in the price transmission analysis.[10] In addition, the short– and long–run speeds of adjustment are rather small in magnitude for both types of rice markets, which suggests that the high and low quality rice markets may be weakly cointegrated with their respective Kabul, Pakistani and global markets. Although a random shock in Kabul, Pakistani and global markets of high and low quality rice affect their respective provincial markets in various degrees, the extent of response showed by the provincial markets is very low. This also indicates that the rice markets may be weakly integrated. Moreover, a comparison of the elasticity (extent) of price transmission among high and low quality rice markets revealed that it is relatively larger for low than high quality rice markets among the pairs of domestic and Pakistani as well as domestic and global markets of high and low quality rice. The comparison yielded equal number of large elasticities for the pairs of provincial and Kabul markets of high and low quality rice, however.

Since the dynamics of price transmission are different between high and low quality rice markets, considering rice as a differentiated commodity in the spatial price analysis not only improves our understanding of the structure of rice markets but also enhances the efficiency of policy recommendations. The integration of high and low quality rice markets with their respective Kabul, Pakistani and global markets indicates that domestic markets of high and low quality rice are exposed to shocks in global and regional rice markets. This calls for appropriate precautionary measures to soften the magnitude of shocks. Although the provincial markets of high and low quality rice are integrated among themselves, the farmers are not well–integrated into the markets, which are occupied by imported rice from Pakistan. Appropriate measures are needed to improve market participation and competitiveness of the farmers as well as to enhance market integration and reduce market imperfections among the domestic markets of high and low quality rice. Implementation of such measures may allow the farmers to gradually benefit from trade liberalization and the country's recent membership of the WTO.

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