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Market Integration and Price Transmission in Tajikistan's Wheat Markets: Rising like rockets but falling like feathers?

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Abstract.

Studies on food price transmission and market integration, particularly in less developed countries, have received increased attention since the recent so-called 'food crises'. They help us understand implications of price relationships in different markets on food security and livelihoods in food insecure countries in an interconnected world. However, despite wide coverage of areas, Central Asia received limited exposure. This paper aims to fill this gap and study wheat market integration and price transmission in Tajikistan, the most food insecure country in Central Asia. In particular, in this study we measure how well wheat market prices in Tajikistan are integrated with international and regional markets, as well as domestically with each other. Subsequently, we assess the nature of price transmission between these markets. Using horizontal price transmission analysis we specifically focus on asymmetric price relationships, a.k.a. rockets and feathers, between different markets.

Keywords Food security, market integration, price transmission, Central Asia, Tajikistan

JEL codes: Q11, Q18

1. Introduction

Studies focusing on role of markets, particularly integration of markets, and transmission of food prices between food abundant and food deficit places have been receiving a lot of attention since the so-called ‘food crises’ of 2007-2008 and 2010-2011. This rendered spurt of conducting empirical research to analyse price relationships of major food products more thoroughly and study implications on food security and livelihoods in food insecure countries.

Studies covered wide range of trade and development policy issues, such as trade restrictions, alternative energy resources and biofuels, etc., which had differing effect on food markets and price transmission (e.g. Serra and Zilberman 2013; Goetz et.al 2013). Studies also captured different aspects of price transmission both in horizontal price transmission, i.e. between markets in different locations, or vertical price transmission along a value chain of a food product (e.g Esposti and Listorti 2013; Frey and Manera 2007; Hassouneh et al. 2012; Brummer et al. 2009).

While studies covered wide geographic area and focused on regions like Northern and Sub-Saharan Africa, Southern America, Middle East, Eastern Europe and South-East Asia, very limited number of studies, however, focused on Central Asian as a region or specific country in the region, as a case study. Only three research work known to authors, which explore food markets in Central Asia from price transmission perspective, are by Brosig and Yahshilikov (2005), which focuses on wheat market integration and price transmission in Kazakhstan; Akramov and Shreedhar (2012) and Abassian (2005), which study only long-run wheat price transmission in Tajikistan without exploring short-run or dynamic relationships. This paper aims to fill this gap and study market integration and price transmission between international, regional and different domestic wheat markets in Central Asia, with a specific focus on Tajikistan, the most food insecure country in Central Asia.

In particular, the paper will try to address two research questions. Firstly, we try to measure how well wheat market prices in Tajikistan are integrated with international and regional wheat prices, as well as domestically with each other. Subsequently, we assess and test the nature of price transmission between different local markets in Tajikistan and price transmission from international and regional wheat markets to local markets in the country. Using horizontal price transmission analysis we specifically focus on asymmetric price relationships, a.k.a. rockets and feathers, between different markets. For this purpose we adopt Asymmetric Error Correction Model using Threshold Autoregressive (TAR)/ Momentum- Threshold Autoregressive (M-TAR) Model specifications proposed by Enders and Siklos (2001).

The contribution of this paper is twofold. Firstly, because there is very limited study on integration of food markets and price relationships amongst food markets in Central Asia including Tajikistan, the paper will contribute to the understanding of wheat markets in Central Asia, particularly from market integration and price transmission perspective. Secondly, we hope Tajikistan case study, based on its different socio-economic, geographical and institutional context, will contribute to the improvement of our understanding of asymmetric price transmission - the rockets and feathers phenomenon, and its importance for food security in food insecure countries in an interconnected world. Although this study does not dwell in particular with reasons or determinants of the rockets and feathers pattern, it, however, pinpoints stimulation of further discussion on the importance of price relationships in spatially different markets and policy implications for food security in respective locations.

The rest of the paper is organised in the following way. In the next section, we provide an overview of food security condition in Tajikistan. The section briefly discusses the importance of wheat trade and role of Kazakhstan wheat exports in the region including Tajikistan. The third section describes theoretical framework and empirical methods used in the analysis. Subsequent sections will describe empirical results; provide some arguments for discussion and conclusion.

2. Overview of food security conditions and wheat markets in Tajikistan

2.1. Food security condition

Tajikistan is a small land-locked, low income and food-deficit country. With about 8.2 million people and around 143 thousand square kilometre area Tajikistan is ranked 98th in the world in terms of both territory and population, according to latest World Bank (2015) estimates. The country is mountainous with limited arable land - only 7 percent of the total land is suitable for arable farming. Approximately 74 percent of its population reside in the countryside and about 55 percent of the labour force is employed in the agricultural sector. With total GDP of about 5.64 billion USD in 2010 and 820 USD per capita (or with PPP 2,147 USD per capita), the economy is amongst the least developed countries in transitional economies (TAJSTAT 2013b, WB 2011).

Just like any other Central Asian countries, Tajikistan suffered a dip in terms of economic growth during early post-independence period. However, unlike any other Central Asian country, the magnitude of the collapse in the economic growth in Tajikistan was heightened from a civil war, which lasted over five years from 1992 to 1997. The civil war took more than 50 thousand lives and displaced millions of people. The conflict directly affected 40 percent of the population and most severely in the eastern parts of Tajikistan in Gharm and Pamir area (UN 2004; DeRouen and Heo 2007). Besides destroying livelihoods and ruining infrastructure, the conflict also prompted large number of professionals and skilled labour to emigrate to neighbouring and other post-soviet countries.

The economy achieved its first post-independence positive GDP growth in 1997 and followed with a remarkable growth rate at about 7.2 percent in average from 1997 to 2012 (ADBI 2014). Particularly, the economic growth surged during 2000 - 2008 year period with an average growth rate of over 8 percent only to be hindered by the global financial and food crises. While the country was able to decrease its poverty headcount ratio from 72 percent in 2003 to 53 percent in 2007, declining remittance inflow and increasing food prices stagnated the rate of poverty alleviation. In fact, two major sources for poverty alleviation in the country according to the WB (2013) have been an increase in wages and remittances with contributions believed to be 50 percent and 30 percent respectively. Nonetheless, with about 47.2 percent of the population living under poverty line Tajikistan is still amongst the least developed nations in transition (Akramov and Shreedhar 2012; WB 2013).

Tajikistan is a net food importing country. In fact, it is heavily reliant on food and energy imports. Imports constitute above 50 and 90 percent of domestic food and energy consumption respectively (FAOSTAT 2013; IEA 2014). More than 50 percent of cereals, 30 percent of bovine beef, 80 percent of poultry products, three-quarters of vegetable oils, and most of sugar consumption in Tajikistan rely on imports. Therefore, spikes in global prices during the global food crises in 2007-2008 and 2010-2011 came as an external shock, which aggravated the food security situation in Tajikistan. Akramov and Shreedhar (2012) suggest that the country spent about 35 to 40 percent of export earnings for food imports, or more than 12 percent of total earnings, if we include earnings from remittances, pressurising foreign exchange and trade balances at the macro level. At the micro level, high food prices pushed poor households to stiffen their budget and forgo quality of diet relying more on single staple food such as wheat products. Additionally, more than half of households reported reduction in staple food consumption because of increased food prices, once again, emphasizing price effect on food consumption patterns.

Food security strategy of Tajik Government is reflected in its “Agrarian Policy Concept, Food Security and Agriculture Investment Plan” within the National Development Strategy for 2006 – 2015; Poverty Reduction Strategy for 2010 – 2012; National Food Security Strategy of 2008; and Law on Food Security in 2010. Governmental Decree on Food Security Programme from 2009 until 2015 supports the national strategy, and the government established the Food Security Council of the Republic of Tajikistan (FSCT) to coordinate strategic decision making concerning food security in the country (IMF 2010; FTF 2012).

Reflecting on previous studies, Akramov (2011, 2012) suggests structural changes in land and agriculture in Tajikistan have had positive impact on the food security in the country in several ways. Firstly, land and farm restructuring enabled improvement in productivity showing smaller private farms being significantly more productive than bigger collective farms. Secondly, allowing resource allocation based on market conditions and changing crop patterns more towards food crops increased domestic food availability. FAOSTAT (2013) estimates indicate that Tajikistan reduced area under fibre crops from 0.285 million hectares in 1992 to about 0.2 million hectares in 2011, a decrease by about 30 percent. During the same period, area under wheat increased from 0.183 million hectares to 0.311 million hectares; and overall cereals from 0.273 million to 0.410 million hectares, an increase by almost 59 percent and 66 percent respectively. Similar increasing trend is experienced in land allocation for tubers and root crops. As a result, two major crops – cotton and wheat, dominate Tajik agricultural system.

Sectorial reforms, liberalisation of the economy and labour, and political stability improved food availability, increased household incomes and achieved strong economic growth. Increased incomes accompanied with increasing inflow of remittances has not had only positive impact on food security in general, but also played a significant role in changing preferences for foods and partially increasing food prices. For instance, Abassian (2005) argues that increased household incomes contributed to increasing food prices and demand for higher quality food commodities such as wheat flour imported from Kazakhstan.

2.2. Wheat supply markets and trade

Wheat is the single most important staple commodity in the country. It provides about 52 percent of the daily calorie intake, and constitutes more than 57 percent of protein intake and 23 percent of fat intake per day per capita in 2009 (FAOSTAT 2013). This makes wheat availability as the single most crucial factor for food availability in Tajikistan. Overall, wheat availability in Tajikistan has increased by more than 2.5 times over a period from 2000 until 2013, as shown in Figure 1. Domestic production increased from about 0.41 million tonnes to over 0.9 million, while import of wheat commodities also increased by almost same magnitude from 0.47 million tonnes to 0.9 million tonnes. Import volume has been increasing rather steadily since 2004, mainly due to increasing volume of wheat flour, whereas production of wheat has been volatile and heavily dependent on weather condition and droughts in seasons in 2000/2001, 2007/2008 and 2010/2011. Moreover, domestic wheat stocks also have increased by more than 10 times from 0.05 to 0.55 million tonnes during the same period.

ADBI (2014) describes Tajikistan as the most trade-open economy in Central Asia in terms of ratio between exports and imports of goods, and GDP. It is the only country in the region whose international trade value has grown in 2000-2012 period compare to 1990-1999 period and which increasingly exceeds its GDP over two periods. Tajikistan is the second country in Central Asia accepted to the World Trade Organisation (WTO), in 2013, after Kyrgyzstan, in 1998. Nonetheless, trade ratios to GDP and accession to the WTO does not reflect on other aspects of trade openness and does not show serious impediments to trade such as geographical location, lack of transportation links and trade regulation institutions, such as check-point and customs procedures, which hinders transportation of goods from one point to another domestically as well as internationally.

Trade in Tajikistan is based on land communications, just like in most of Central Asia. Rail road and traffic connections of the land locked country is also restricted with mountain ranges. In relation to the wheat trade, Kazakhstan is the main and only net exporting country in the region. Its proximate positioning than other regional competitors such as Russia and Ukraine makes it dominant exporter in the region. Table 1 shows that Kazakhstan fulfils more than 90 percent of the wheat import requirements of Central Asian countries including Tajikistan. At the same time, Central Asian wheat market is the biggest single export market for Kazakhstan producers accounting for about 44 percent of the total Kazakh export volume in 2011.

Also noteworthy that several studies highlight significant of share of informal trading in the region. Robinson (2008) and Abassian (2005) suggest informal trade particularly of wheat commodities could be at least as big and important as formal trade volumes. For instance, Abassian (2005) claims that informal import of wheat flour might comprise 70 percent of total wheat flour import in Tajikistan.

Beside domestic production and import of food, Tajikistan has been one of the biggest donor food recipients in the region. FAO statistics suggest that international community has been rather responsive during times of major turbulences and environmental disasters such as during the civil war between 1992 and 1997, or major weather anomalies in 2001-2002 and 2005-2006 by providing food aid mainly in the form of grains. However, the tendency of food donation has been in decline and Tajikistan latest received considerable amount of food aid only in 2007-2008, due to the global food crises.

3. Theoretical framework and empirical method

In general, the key theoretical concept in spatial price transmission analysis is spatial arbitrage, which implies that difference between prices of homogeneous goods in different markets places is only subject to transaction costs. Therefore, most of empirical works in spatial price transmission analysis aim at assessing whether the *Law of One Price* (LOP) holds true or not (Listorti and Esposti 2012). Fackler and Goodwin (2001) provides very useful description of conceptual framework and definitions of spatial price transmission, which we adopt in this analysis. Maybe it is worthwhile to note that we assume ‘weak’ LOP defined by Fackler and Goodwin (2001) which is characterized by having a spatial arbitrage in the form of:

$$p_t^D - p_t^E \leq c_{ij}$$

Here, p_t^D is wheat price at a destination market, p_t^E represents the wheat price at a market of origin, and c_{ij} is a transaction cost of shipping a good between markets. Moreover, we assume less restrictive notion of market integration in which price differences may exist in the short-run but in the long-run arbitrage will not allow prices between respective markets drift apart therefore they move together.

For the analysis price relationships cointegration techniques proposed by Engle and Granger (1987) and Johansen Maximum Likelihood method (Johansen 1988) are widely used. Both of the methods assume linear and symmetric relationships between variables. Standard Johansen methodology starts with a vector autoregressive model and the reformulates it into a vector error correction model (VECM) as follows:

$$X_t = \pi_1 X_{t-1} + \cdots + \pi_k X_{t-k} + \zeta_t \qquad (1a)$$

$$\Delta X_t = \sum_{i=1}^{k-1} G_i \Delta X_{t-i} + \Pi X_{t-k} + \zeta_t \qquad (1b)$$

Here, X_t is an (n x 1) vector of price variables which are integrated of order one $I(1)$, k is number of lags, and ζ_t is an (n x 1) vector of the normally distributed disturbances, $G_i$represents dynamic effects while Π captures the long run effects of the analysed series. The Johansen ML test estimates the rank of the Π matrix, i.e. the number of cointegrating relationships.

In Engle and Granger (1987) two-step specification, the long-run price transmission is given by the slope parameter $\beta_1$in the equation:

$$p_t^D = \beta_0 + \beta_1 p_t^E + \varepsilon_t \qquad (2)$$

Here, p_t^D and p_t^E are wheat prices in two different markets which are integrated of degree one, $I(1)$; $\beta_i$is a degree of long-run price transmission (cointegration); and, $\varepsilon_t$is an error term which might be serially correlated.

In the second step, residuals form the equation (2) are obtained and $\theta$is estimated. Null hypothesis of no co-integration (or, $\theta = 0$) tested in the following regression:

$$\Delta\bar{\varepsilon}_t = \theta\bar{\varepsilon}_{t-1} + \sum_{i=1}^{m} f_i \Delta\bar{\varepsilon}_{t-i} + u_{it} \qquad (3)$$

u_{it} is a white noise disturbance. Rejecting the null hypothesis of no co-integration would mean pair of wheat prices are cointegrated and that they move together in the long-run. Subsequently, error correction model captures dynamic relationships (ECM) (Engle and Granger 1987):

$$\Delta p_t^D = a_0 + a_1\bar{\varepsilon}_{t-1} + \sum_{i=1}^{n} f_i \Delta p_{t-i}^D + \sum_{j=1}^{n} g_j \Delta p_{t-j}^E + u_{it} \qquad (4)$$

Where, $a_1$is a speed of adjustment; $\bar{\varepsilon}_{t-1}$is a lagged residual from long-run equation; Δp_t^D and $\Delta p_t^E$are vectors of first differences of log prices; u_{it} is a white noise disturbance.

As mentioned above, Engle and Granger (1987) and Johansen (1988) tests implicitly assume a linear and symmetric adjustment mechanism. Following Balke and Fomby (1997)and Enders and Siklos (2001) recommendation it is appropriate to use Engle-Granger test to determine whether the variables are co-integrated. However, if nonlinearity, such as asymmetric adjustment, is suspected then addressing nonlinear adjustment is appropriate. We use threshold autoregressive (TAR) and momentum threshold autoregressive (M-TAR) models developed by Enders and Siklos (2001) to test for co-integration and estimate asymmetric adjustments in the dynamic relationship.

The following equation represents the TAR model:

$$\Delta\bar{\varepsilon}_t = \theta_1^+ I_1 \bar{\varepsilon}_{t-1} + \theta_1^- (1 - I_1)\bar{\varepsilon}_{t-1} + \sum_{i=1}^{k} \nu_i \Delta\bar{\varepsilon}_{t-i} + u_{it} \qquad (5)$$

where $\Delta\bar{\varepsilon}_t$ is the first difference of the residuals obtained from equation (2) and $\theta_1^-$and θ_1^+ are adjustment rates. I_1 is a Heaviside indicator function such that:

$$I_t = \begin{cases} 1 & if\ \bar{\varepsilon}_{t-1} \geq \tau \\ 0 & if\ \bar{\varepsilon}_{t-1} < \tau \end{cases} \qquad (6)$$

where τ is a threshold value. Logically, one can assume that natural attractor for an equilibrium between two prices would be zero. However, there could many reasons not to expect that true threshold coincides with the natural attractor. One obvious reason would be transaction cost. Therefore, true threshold value is obtained using a method proposed by Chan (1993). Chan (1993) shows that searching for the threshold value so as to minimize the sum of squared errors from the fitted model yields a super-consistent estimate for the threshold.

Enders and Siklos (2001) suggests that if $\bar{\varepsilon}_t$ series exhibits more “momentum” in one direction than the other in a way, for instance, equilibrium condition is more powerful attractor for negative values than for positive values, then M-TAR specification in the following equation would be more appropriate.

$$I_t = \begin{cases} 1 & if\ \Delta\bar{\varepsilon}_{t-1} \geq \tau \\ 0 & if\ \Delta\bar{\varepsilon}_{t-1} < \tau \end{cases} \tag{7}$$

Also suggested by Enders and Siklos (2001), M-TAR modification of the Engle-Granger (1987) has shown better power and size properties when indeed asymmetric relationship between pairs of prices prevails.

We correspond to the short-run price transmission as the speed of adjustment (δ) of the error correction term ($\bar{\varepsilon}_{t-1}$). Splitting them into positive and negative deviations from the long-run equilibrium makes it possible to test for asymmetric price transmission:

$$\Delta p_t^D = a_i + \delta_1^+ I_t \bar{\varepsilon}_{t-1} + \delta_2^- (1 - I_t)\bar{\varepsilon}_{t-1} + \sum_{i=1}^{p} f_i^+ I_t \Delta p_{t-i}^D + \sum_{i=1}^{p} f_i^- (1 - I_t)\Delta p_{t-i}^D + \sum_{j=1}^{p} g_j^+ I_t \Delta p_{t-j}^E + \sum_{j=1}^{p} g_j^- (1 - I_t)\Delta p_{t-j}^E + u_t \tag{8}$$

By further splitting autoregressive first differences of prices Δp^D and Δp^E into positive and negative components we further allow for more complex dynamic effect (Meyer and Von Cramon-Taubadel 2004).

4. Data and methodology

In this paper, we use wheat markets prices from six different locations or markets. Wheat prices from French port of Rouen represent international wheat prices. Rouen port is the closest major grain market to the Black Sea market, which includes Russia, Ukraine and Kazakhstan. Saryagash is a Kazakh border town with Uzbekistan from where most of wheat is transported to Tajikistan through railroads crossing as shown in Map 1. Other four markets represent Tajik domestic markets. Dushanbe is the capital city, which supplies the urban population and is the primary market for importers and for distribution to the entire country. Khujand is a major *'trade-hub'* city in the north of the country with strong trade connections with other parts of the Fergana Valley in Uzbekistan and Kyrgyzstan. Kurgan-Tyube is a *'bread-basket'* in the south of the country comprising more than 60 percent of the total wheat area in the country. Gharm is rather small and isolated market with about 8 thousand inhabitants, and supplies the chronically food-insecure Rasht Valley in the east.

In the empirical analysis, we use monthly data from January 2002 to December 2013 obtained from World Food Programme (WFP), which operates in Tajikistan as one of the main food aid donors and collects markets prices in several markets throughout the country. The prices, collected from traditionally popular market places ('bazaars') in certain cities/towns, represent spot market consumer prices. International wheat price in Rouen is obtained from HGCA website. Saryagash prices are obtained from Kazakh-Zerno Information Agency – one of leading agricultural market information centres in Kazakhstan.

As mentioned in the earlier sections, almost whole international wheat trade in Tajikistan involves wheat imports from Kazakhstan. Transportation of a good from Kazakhstan to Tajikistan through railroads takes less than a week, in general, unless there are border closures, which might happen time-to-time for different reasons unpredictable for traders. In addition, mobile phones and advanced communication technology makes the flow of market price information very fast and more frequent. Therefore, high frequency price data such as weekly data would be more suitable for our price transmission analysis. However, as Hassouneh et al. (2012) suggests, availability of a good quality time series data is a common problem in developing countries, and it is better to assess the impact of food scares in those countries with lower frequent data rather than leaving the question unexplored.

We use monthly average exchange rates obtained from National Bank of Tajikistan (2014) to turn into a single currency in Tajik Somoni and use natural logarithms of real prices. In order to estimate price transmission coefficients certain properties of individual price series should be tested and assured before cointegration analysis. Particularly, the price series are tested for stationarity in order to avoid spurious regression results (Hamilton 1994). For this purpose, we use the augmented Dickey Fuller (ADF) (Dickey and Fuller 1979) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test (Kwiatkowski et al. 1992). The former test has a null hypothesis that the series have a unit root thus implying nonstationarity. Whereas, the latter is strong null hypothesis that a time series is stationary and, therefore is well suited for robustness check.

In order to be able to proceed to cointegration test we need to verify that individual price series are integrated at the same order. Subsequently, we conduct tests for cointegration proposed by Johansen (1988) Maximum Likelihood tests and Engle and Granger (1987) as a robustness check. In the case of the latter test, Engle and Granger (1987) propose seven test statics for testing the null of no co-integration against the alternative of co-integration. Amongst these tests the authors recommend the ADF has essentially the same critical values for both finite and large sample experiments, and as nearly good observed power properties in most comparisons. As a robustness check for unit root in the error term of the cointegration equation we use Phillips-Perron (PP) test (Phillips and Perron 1988).

In the pre-final estimation stage, we used Threshold Autoregressive model (TAR) and momentum threshold autoregressive models (M-TAR) to test asymmetric adjustment as in equation (5) with specification of (6) and (7) respectively. Almost in all cases AIC and BIC demonstrate that M-TAR specification fits the data better as was suggested by many other works (Enders and Granger 1998, Enders and Siklos 2001, Sun 2011, etc.). Only in one occasion, in the case of Gharm and Khujand, TAR estimates are very slightly superior to M-TAR specification according to both information criteria. Thus, momentum equilibrium asymmetric adjustment is considered in estimating our vector error correction model. Finally, error correction model with symmetric adjustment in mind as in equation (4) as well as asymmetric adjustment as in equation (8) are estimated.

Throughout the model estimations, we consult BIC and AIC criteria in order to choose best-fit model specification with appropriate number of lags selected and Ljung-Box (LB) statistics to make sure that there are no serial autocorrelations with the error terms.

5. Empirical results

An observation of price developments and trends could be a good starting point. Figures 2 and 3 show monthly wheat prices - presented in lines, and Tajikistan wheat imports volumes - presented in bars, over the twelve-year period from 2002 till 2013. For the ease of visualization, we separated the figure into two. Figure 2 shows that Dushanbe wheat price is little bit more volatile than both Rouen and Saryagash prices. At the same time, Dushanbe price seem to follow both prices well and adjust fast especially during price jumps. This, however, cannot be said when the opposite occurs and Dushanbe price ‘hangs’ longer when other regional and international prices fall. This is particularly more evident between Dushanbe and Saryagash prices and particularly during the second wave of international food crises in 2010/2011. Though in smaller scale and less salient ‘hanging’ of prices after 2004 and 2007/08 price spikes are also visible. Figure 2 also shows that volume of imports tends to be increasing since 2004, the earliest monthly trade data available for Kazakhstan monthly wheat export through Global Trade

Information System (GTIS) database. Moreover, volume of wheat imports tend to be higher in late autumn and early winter times in Tajikistan when local traders stock before winter makes literally impossible to transport goods in some peripheral locations because of bad road infrastructure in the country. As mentioned earlier and reiterated by many country level studies, road infrastructure particularly connecting major cities with peripheral towns and community locations are very poor. Even one of nationally most important road links, if not the most important, between Dushanbe and Khujand is often closed during heavy snows in the winter. The same is relevant to Gharm and other location in the Eastern Tajikistan, where some markets might become isolated for weeks.

Figure 3 shows four different market prices in Tajikistan. Dushanbe wheat price in the middle of the pack, most of the time, while Gharm prices on top and Kurgan-Tyube prices at the bottom. The lines also show that over the period the gap between prices have increased. If it is difficult to figure out lines from each other until 2004, the gap is more visible beginning from 2005 and increasing particularly after 2007/08 and 2010/11 price shocks. Similarly, local prices as a group tend to react to price changes more or less instantaneously before the 2007/08 food crisis, whereas their adjustments tend to differentiate in post-price-peaks. Again, Gharm prices hanging above the rest of the group. Finally, it seems all prices demonstrate fairly non-stationary behavior.

Formal stationarity test results are presented in Table 2. The ADF fails to reject the null hypothesis of a unit root in levels and rejects the null hypothesis for the first difference of each price series. The KPSS test supports the results by rejecting the null hypothesis of stationarity for each price series in levels, and failing to do so for the corresponding first differences. We also run tests for cases with trend. Results showed that inclusion of a trend term in the series did not alter the test results. Thus, we conclude that all individual wheat price series are integrated of order one, I(1).

Concluding that all price series are I(1) allows us to run cointegration analysis. The Johansen ML test estimations in Table 3 show that all but one (Gharm and Rouen) price series are cointegrated of order one, I(1), at 5 percent or lower significance level. Gharm and Rouen price series are cointegrated at 10 percent level. There are two potential reasons. On one hand, and more obvious reason is that Gharm is a small and rather isolated market and price signals from international markets might carry weak reflection on local prices and take longer time. On the other hand, Johansen ML tests assumes symmetric relationships whereas adjustments could be highly asymmetric.

Engle-Granger cointegration test results are provided in Table 4, as a robustness check. In all cases, the ADF tests reject non-stationarity and, therefore, reveal the existence of cointegration relationship between each and individual pairs. Phillips-Perron (PP) test supports the notion and the Ljung-Box Q statistic indicates no serial correlation.

Given these results, we can argue that, in the long-run, Tajik wheat prices are cointegrated with regional and international wheat prices as well as amongst each other. Long-run price transmission elasticity between different market prices or degree of cointegration are shown in Table 5. The price transmission elasticity indicates the percentage change in the wheat price of local Tajik market in response to a 1 percentage change in another market. Numbers in bold between Gharm and Saryagash, Khujand and Saryagash, and Kurgan-Tyube and Rouen represent the degree of cointegration which are not significantly different from 1.0 (at 95% confidence level), therefore perfect degree of co-movement of prices in the long-run cannot be rejected. Overall, in the long run 1 percentage change in price in an independent market price results in 0.96 percentage change in a dependent market price. This figure is in par with an average long-run price transmission coefficient prevailing within European wheat markets at 0.94 (Gillson and Fouad eds. 2015), which is highest in the world, demonstrating very high level of co-integration between wheat markets.

Nevertheless, unlike in European wheat markets, analyses of more dynamic relationship shows nonlinearity. The M-TAR estimates in Table 6 shows that indeed asymmetric adjustments in more dynamic price relationships is more prevalent than symmetric relationships. The Φ statistic allows us to reject the null hypothesis of no cointegration at 5% or higher level, in most of the cases except for Kurgan Tyube, suggesting that most price pairs are cointegrated but with threshold M-TAR adjustment. The AIC numbers from Table 4 and Table 6, supports the argument that cointegration with M-TAR specification has better fit in most of the occasions except for, again, Kurgan Tyube cases. The F test for symmetric adjustment also follows the Φ statistic indicating that the adjustment mechanism is asymmetric. Having more negative threshold (τ) estimates show that in most cases negative discrepancies from the long-term equilibrium are eliminated more quickly than positive discrepancies. In other words, prices react to price increases faster and establish the balance faster than if prices would decrease.

The positive finding of cointegration with the Engle-Granger's ADF test and in most of the cases with M-TAR adjustment justifies estimation of error correction in the both forms of equation (4) and (8). The result of error correction model estimates are presented in Table 7. Each respective Tajik market mentioned as a dependent variable in the table is regressed separately against different market prices in columns. Three rows under symmetric error correction model show parameter estimates for short-run price transmission elasticity or speed of adjustment (δ_1), their t-values and AIC for a model fit with symmetric adjustment specification. Below that asymmetric error correction model estimates follow, which are presented by speed of adjustment parameters with their t-values; three different hypotheses of asymmetric speed of adjustment effect, cumulative asymmetric effect of lagged own prices and cumulative asymmetric effect of lagged regressor prices; as well as Ljung-Box Q statistic and AIC. The Heaviside indicator in a model with M-TAR adjustment is set in accord with (7). Parameters in shaded area with respective model specification are found to be a better fit according to the AIC.

Results show that speed of adjustment of Dushanbe wheat prices symmetrically adjusts towards wheat prices in Rouen, Khujand and Kurgan-Tyube with more or less the same magnitude of about 20-25 percent of the discrepancy is adjusted during one lag of period that is in one month. However, adjustment of Dushanbe wheat prices seem to be asymmetric towards Saryagash wheat prices. It shows that adjustment towards a negative discrepancy (namely to a price increase in Saryagash) from the price equilibrium is much faster with about 35.7 percent discrepancy is adjusted in one period. On the contrary, adjustment towards positive discrepancy is only 7 percent in one period and significant at only 10% significance level. Moreover, asymmetric error correction shows that Dushanbe wheat prices do not necessarily adjust to Gharm wheat prices with no significance at 5% level. This contains more economic sense compare to the parameter estimate (-0.14) obtained through symmetric error correction model. As we have reiterated, Gharm is a small market and it is very unlikely and wrong to expect Dushanbe prices to adjust to Gharm prices.

Contrary to Dushanbe wheat prices, the AIC figures show that Gharm wheat price adjustment mechanism towards other market prices is strongly asymmetric. Gharm prices adjust very fast to price increases in other markets ranging from 35 to 60 percent of the discrepancy is adjusted in a single period. At the same time, it seems there is very little or no significant adjustment towards price decreases in the short run except towards Dushanbe price. Having significant adjustment of Gharm wheat prices towards both price increases and price decreases in Dushanbe prices is a reflection of Dushanbe being the closest major wheat market to Gharm and most likely that price transmission between Gharm and other wheat market prices occur through the prism of Dushanbe wheat market conditions.

Similarly, Khujand wheat prices also show strong asymmetric adjustment mechanism towards other wheat market prices. Khujand wheat prices adjusts very fast to price increases ranging from 22 percent in Saryagash case to almost 87 percent in Dushanbe case. Like other major wheat markets in Tajikistan, Khujand wheat prices do not adjust to Gharm wheat prices, which makes economic sense.

In contrast to other major wheat markets in Tajikistan, Kurgan-Tyube wheat prices demonstrate very interesting pattern of price relationship towards other international and local wheat markets. The AIC numbers for both symmetric and asymmetric error correction models are very close to each other, therefore precautions about arguments for asymmetric price adjustment mechanisms should be made. The AIC estimations are marginally higher thus supports symmetric error correction model specification towards international market, and marginally lower thus supporting asymmetric specification of the error correction model towards other domestic Tajik markets. In both model specifications, Kurgan-Tyube wheat prices seem not to adjust much towards regional wheat prices in Saryagash. However, negative signs in the speed of adjustment parameters supports the argument for cointegration between Kurgan-Tyube and Saryagash prices. Similarly interesting that only Kurgan-Tyube wheat prices demonstrate faster adjustment towards price decreases in other markets. One of the plausible explanations for this phenomenon is that Kurgan-Tyube is a ‘bread basket’ region in the country, as mentioned in the earlier sections, thus have enough market as well as local stocks to alleviate price increase shocks. Therefore, Kurgan-Tyube adjusts to price decreases in other places, albeit not very fast with only about 20 percent of the discrepancy adjusted in one period, but does not necessarily adjust to price increases exploiting available local resources and stocks.

6. Discussions and concluding remarks

Our estimations show that indeed Tajik local wheat market prices are cointegrated with international and regional markets as well as amongst each other, which is essential for maintaining sustainable food security in a food insecure economy. However, our results also show that domestic market prices adjust more quickly to price increases in other wheat markets. Evidence of substantial and significant positive asymmetry in peripheral markets such as Gharm market indicates prevalence of asymmetric price transmission which jeopardizes wheat availability particularly in peripheral food dependent markets. At the same time, evidence of prevalence of negative asymmetry in 'bread basket' regions such as Kurgan-Tyube suggests that there are pockets of locally available resources and capacity. Existence of two contrasting price adjustment mechanisms exacerbates price gaps between food-dependent and food producing regions. It also puts considerably more pressure on the poorest households in the food-dependent regions during price hikes.

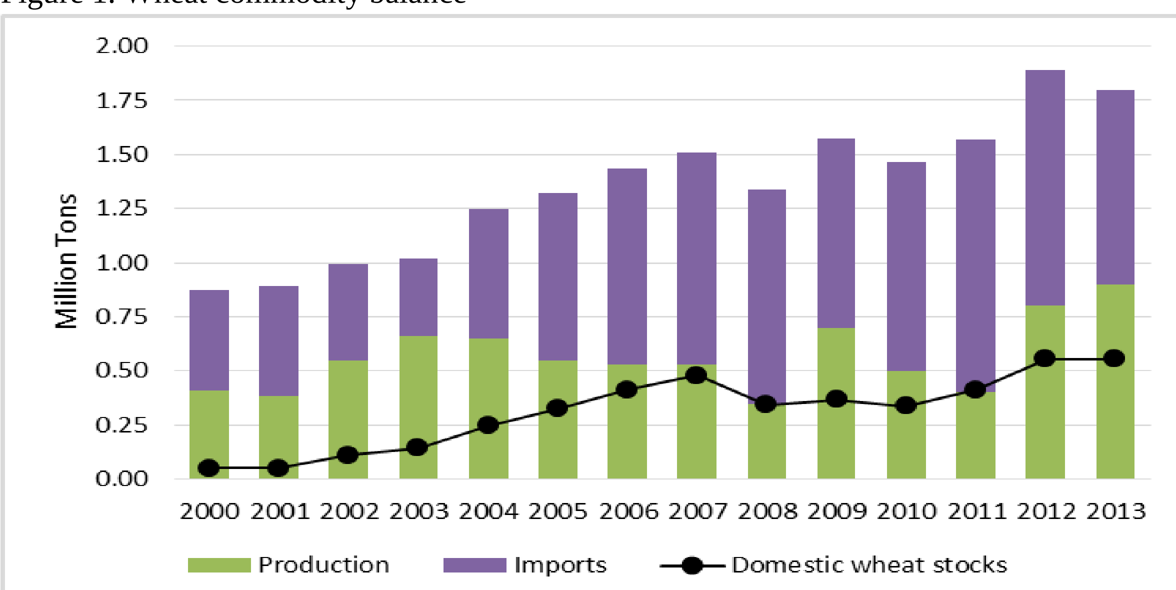
Exploring determinants of such asymmetric mechanism is beyond the scope of this paper and requires through market analysis including formal and informal rules, regulations, networks, and pricing mechanisms. However, this study highlights the importance of trade and market integration in the country as well as in the region for sustainability of food security. Although Tajik government has taken major steps to improve food security in the country as discussed in the second section of the paper, the main direction of the national strategy on food security envisages achieving food security mainly through improving agricultural productivity and attaining self-sufficiency in major food commodities. Unfortunately, role of domestically, regionally and internationally integrated markets and trade do not receive enough emphasis within national policies. Moreover, as Ecker and Breisinger (2012) point out availability of food, despite being the first and important pillar for food and nutrition security is the one of four pillars for extended food security; the rest three are being access, utilization and stability. Therefore, it is advisable for Tajik government to acknowledge that the issue on the supply side of the equation, and particularly a country's ability to provide enough food for domestic consumption through production, is the only one side of the story and more comprehensive approach for food security should be considered. Existence of both relatively food scarce and relatively food abundant regions indicate that government should take more active role in supporting the interconnection of these regions and flow of food and other resources through eliminating barriers and lowering transaction costs.

Often transportation is considered the main constituent of transaction cost. This is particularly true when transportation infrastructure is underdeveloped. Bad road infrastructures in Tajikistan naturally incur higher transaction cost between central markets to peripheral markets, and between agricultural areas to food dependent areas. In turn, higher transaction cost accompanied with higher adjustment costs likely to result in more salient asymmetric adjustment mechanism between these two types of markets. Tajik government has stepped up improving transportation infrastructure through various regional programs and projects such as Central Asia Regional Economic Cooperation Program (CAREC) supported multinational donor organizations (WB 2007). However, projects and activities concern more centrally important road links, and addressing the problem at peripheral locations might require more time and may stay untouched until government prioritizes local infrastructure development in those areas. Therefore, in the shorter term appropriate food assistance, income transfers and targeted assistance programs could be relevant in addressing asymmetric impact of regional disparities and food price shocks.

Tables, Figures and Maps

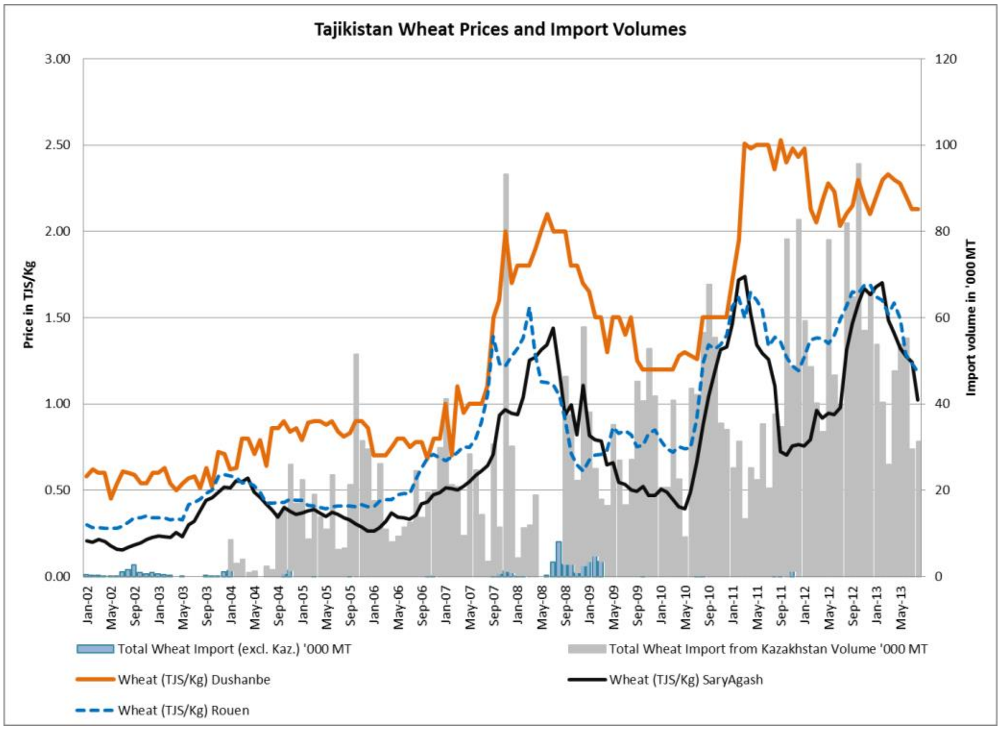
Map 1. Major wheat trade route from Kazakhstan to Tajikistan case study sites

Figure 1. Wheat commodity balance



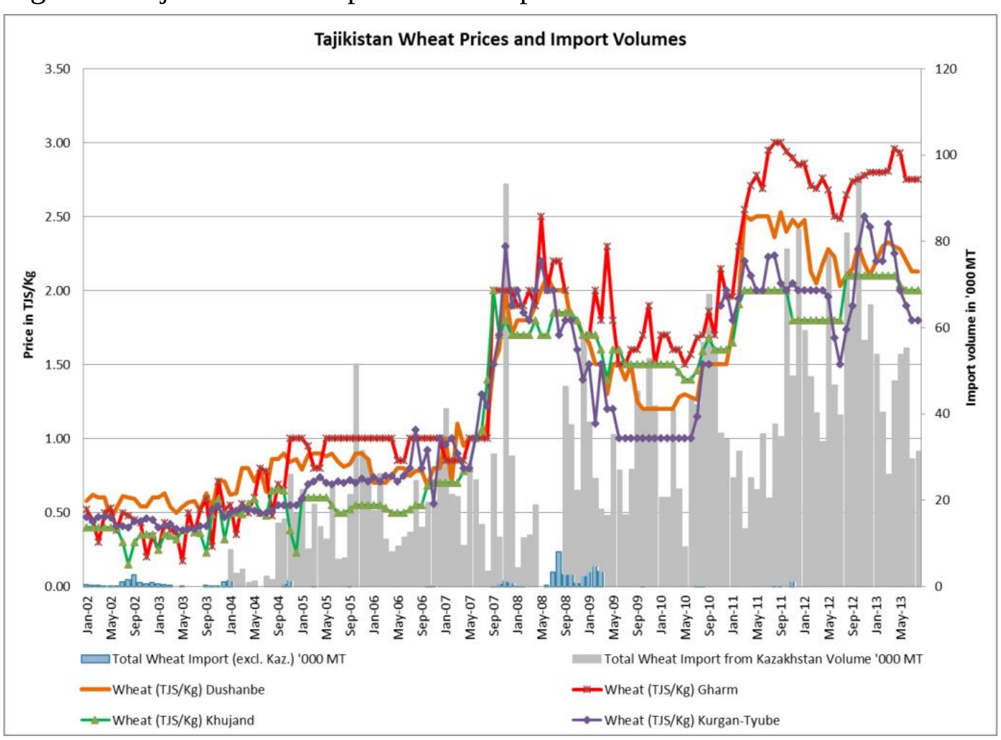
Source: USDA 2013

Figure 2. International (Rouen), regional (Saryagash) and local (Dushanbe) wheat prices



Source: Own compilation using GTIS and WFP databases

Figure 3. Tajikistan wheat prices and import volumes



Source: Own compilation using GTIS and WFP databases

Table 1. Wheat imports of Central Asian countries in 2011

	Kazakhstan		Russia		World	
	volume ('000 MT)	value ('000 USD)	volume ('000 MT)	value ('000 USD)	volume ('000 MT)	value ('000 USD)
Kyrgyzstan	267.5	60,493.9	0.004	4.1	267.5	60,498
Uzbekistan	500	83,457.4	16.8	10,655.9	517.1	94,114.2
Turkmenistan	0.2	0.04	-	-	0.2	0.04
Tajikistan	453.5	97,110.8	1.5	823.9	455	97,935
Central Asia	1,221.5 (43.87%)	241,101.1 (40.77%)	18.3 (0.12%)	11,483.8 (0.32%)		
World	2,784.3 (100.00%)	591,368.9 (100.00%)	15,074.1 (100.00%)	3,640,561.9 (100.00%)		

Source: Own calculations using trade data from Global Trade Information Services (GTI) database, 2013

Table 2. Stationarity test results for wheat prices at markets of interest

	Price series					
	Dushanbe	Gharm	Khujand	KurganTyube	Saryagash	Rouen
In levels	*2 lags*	*2 lags*	*3 lags*	*2 lags*	*3 lags*	*2 lags*
ADF	-1.113	-1.531	-1.029	-1.423	-2.104	-1.596
KPSS	4.26***	4.37***	3.32***	4.11***	2.63***	4.09***
In first differences	*1 lags*	*1 lags*	*2 lags*	*1 lags*	*2 lags*	*1 lags*
ADF	-8.880***	-12.056***	-9.146***	-7.981***	-5.275***	-7.010***
KPSS	.0508	.0297	.0442	.0949	.0784	.0752

* Significant at 10%; **Significant at 5%; ***Significant at 1%
Tests were performed with a constant term and no trend. Number of lags were selected according to the Schwarz's Bayesian information criterion (BIC).

Table 3. Johansen co-integration tests for the wheat price series of interest

Series	H_0 (H_1)	Rouen	Saryagash	Dushanbe	Gharm	Khujand
Dushanbe	r=0 (r>0)	29.6133**	20.497**			
	r=1 (r>1)	2.402	2.4813			
Gharm	r=0 (r>0)	15.3534*	15.7231**	21.2257**		
	r=1 (r>1)	1.9772	2.5951	0.9505		
Khujand	r=0 (r>0)	23.8901**	17.6187**	25.9039**	30.8456**	
	r=1 (r>1)	2.0596	2.3468	0.9326	0.9373	
Kurgan-Tyube	r=0 (r>0)	23.8336**	19.9019**	20.8761**	21.4635**	19.6724**
	r=1 (r>1)	2.1597	0.5001	1.7095	1.563	1.6403

* Significant at 10%, ** Significant at 5%.
Notes: Prices are in natural logarithm. Critical value for trace statistics at 5% for H_0: r=0 and H_0: r=1 are 15.41 and 3.76 respectively. Johansen ML test with an unrestricted constant with two lags specification, except Saryagash – Kurgan-Tyube has 6 lags with a critical value at 5% for H0: r=0 and r=1 being 12.53 and 3.84 respectively.

Table 4. Engle-Granger co-integration tests for the respective wheat price series

Series	Lags[ł]	ADF	ADF (11 lags)	PP[€] (4 lags)	LB (12 lags)	AIC
Dependent variable: natural logarithm Dushanbe wheat price [a]						
Rouen	1 lag	-2.891***	-3.690***	-4.028***	0.2635	-218.463
Saryagash	2 lags	-3.057***	-3.151***	-3.403***	0.7136	-190.905
Gharm	4 lags	-2.527**	-3.054***	-7.361***	0.427	-153.764
Khujand	1 lag	-4.868***	-2.445**	-6.483***	0.3754	-136.836
Kurgan-Tyube	4 lags	-2.378**	-1.994**	-6.231***	0.487	-203.445
Dependent variable: natural logarithm Gharm wheat price						
Rouen	2 lags	-2.687***	-3.400***	-4.247***	0.1779	-40.265
Saryagash	2 lags	-2.677***	-2.903***	-3.883***	0.357	-21.531
Dushanbe	4 lags	-2.502**	-3.177***	-7.681***	0.5246	-61.065
Khujand	4 lags	-2.974***	-2.284**	-7.277***	0.5717	10.684
Kurgan-Tyube	4 lags	-2.446**	-3.220***	-7.574***	0.3559	-36.371
Dependent variable: natural logarithm Khujand wheat price						
Rouen	2 lags	-3.004***	-2.074**	-4.054***	0.4409	-80.558
Saryagash	1 lag	-3.429***	-2.475**	-3.704***	0.3787	-49.122
Dushanbe	2 lags	-3.877***	-2.267**	-6.586***	0.6241	-47.993
Gharm	4 lags	-2.816***	-1.971**	-7.065***	0.6604	4.979
Kurgan-Tyube	0 lag	-5.261***	-2.417**	-5.086***	0.4956	-77.483
Dependent variable: natural logarithm Kurgan-Tyube wheat price						
Rouen	6 lags	-3.265***	-3.424***	-3.582***	0.787	-174.434
Saryagash	5 lags	-2.832***	-2.773***	-3.162***	0.497	-183.265
Dushanbe	3 lags	-2.914***	-2.107**	-6.226***	0.3146	-162.918
Gharm	4 lags	-2.489**	-3.087***	-7.238***	0.3445	-90.192
Khujand	0 lag	-5.164***	-2.680***	-4.984***	0.5845	-131.009

* Significant at 10%; **Significant at 5%; ***Significant at 1%.

Critical values for the ADF and PP are -2.594, -1.950 and -1.613 at 1%, 5% and 10% respectively.

[ł] Number of lags indicate an additional augmented lag change. Lag selection is based on the AIC, BIC and Ljung-Box Q (LB) statistic. [€] Phillips-Perron unit-root test specifies number of Newey–West lags to use in calculating the standard error. The default is to use int{4(T/100)^(2/9)} lags. [a] Residuals obtained from the regression equation: $\ln P_{Dushanbe,t} = a + b^{*}\ln P_{Rouen,t} + e_t$

Table 5. Degree of co-integration estimations in long-run equations

	Rouen	Saryagash	Dushanbe	Gharm	Khujand	Kurgan-Tyube
Dushanbe[a]	.858*** (.0315)	.729*** (.0304)	1	.689*** (.0210)	.694*** (.0213)	.835*** (.0218)
Gharm	1.120*** (.0515)	**.930***** (.0509)	1.282*** (.0391)	1	.920*** (.0344)	1.114*** (.0357)
Khujand	1.155*** (.0438)	**.966***** (.0445)	1.271*** (.0391)	.907*** (.0339)	1	1.109*** (.0348)
Kurgan-Tyube	**.994***** (.0334)	.842*** (.0333)	1.092*** (.0285)	.783*** (.0251)	.791*** (.0249)	1

*Significant at 10%; **Significant at 5%; ***Significant at 1%. Standard errors are in parentheses.

[a] Regression equation: $\ln Price_{Dushanbe,t} = Intercept + b*\ln Price_{City,t} + e_t$, where city denotes cities in the row.

[b] Co-integrating coefficients in **bold** are not significantly different from 1.0 (at a 95% confidence level), therefore perfect degree of co-movement of prices cannot be rejected.

Table 6. M-TAR model parameter estimates

Item	Independent variables [a]					
	Rouen	Saryagash	Dushanbe	Gharm	Khujand	KurganTyube
Dependent variable: Dushanbe wheat price						
No. of lags[ǂ]	0	1	-	11	1	3
θ_1^+	-0.096*	-0.049	-	-0.585***	-0.798***	-0.165*
t-value	(-1.859)	(-1.008)	-	(-4.519)	(-6.1)	(-1.702)
θ_1^-	-0.351***	-0.471***	-	-0.164*	-0.234***	-0.358***
t-value	(-3.956)	(-4.748)	-	(-1.658)	(-2.74)	(-2.952)
H_0: $\theta_1=\theta_2=0$ (Φ)	9.555***	11.563***	-	10.211***	20.451***	4.978
H_0: $\theta_1=\theta_2$ (F)	6.175**	15.267***	-	10.367***	14.855***	1.924
τ	-0.095	-0.139	-	0.06	0.105	-0.118
LB(12)	0.233	0.555	-	0.853	0.842	0.283
AIC	-219.086	-202.045	-	-170.242	-147.254	-197.645
Dependent variable: Gharm wheat price						
No. of lags	1	1	11	-	4	4
θ_1^+	0.022	0.023	-0.098	-	-0.127	-0.096
t-value	(0.349)	(0.359)	(-0.86)	-	(-0.964)	(-0.857)
θ_1^-	-0.535***	-0.386***	-0.531***	-	-0.498***	-0.494***
t-value	(-5.926)	(-4.846)	(-4.594)	-	(-3.849)	(-3.641)
H_0: $\theta_1=\theta_2=0$ (Φ)	17.614***	11.787***	10.8***	-	7.42**	6.64**
H_0: $\theta_1=\theta_2$ (F)	25.868***	15.988***	10.688***	-	5.684**	7.028***
τ	-0.153	-0.129	-0.057	-	-0.036	-0.15
LB(12)	0.082*	0.451	0.813	-	0.678	0.347
AIC	-59.74	-30.487	-85.016	-	8.867	-39.528
Dependent variable: Khujand wheat price						
No. of lags	2	0	1	4	-	0
θ_1^+	-0.009	-0.051	-0.228**	-0.598***	-	-0.19**
t-value	(-0.14)	(-0.875)	(-2.436)	(-3.582)	-	(-2.588)
θ_1^-	-0.574***	-0.483***	-0.716***	-0.213**	-	-0.645***
t-value	-6.05	(-5.911)	(-5.97)	(-1.99)	-	(-5.908)
H_0: $\theta_1=\theta_2=0$ (Φ)	18.319***	17.853***	19.374***	6.788**	-	20.8***
H_0: $\theta_1=\theta_2$ (F)	25.978***	18.558***	11.555***	5.385**	-	11.981***
τ	-0.087	-0.148	-0.136	0.104	-	-0.102
LB(12)	0.539	0.747	0.749	0.82	-	0.637
AIC	-101.041	-64.033	-54.655	3.463	-	-83.72
Dependent variable: KurganTyube wheat price						
No. of lags	6	5	3	4	0	-
θ_1^+	-0.225***	-0.101**	-0.267***	-0.272***	-0.653***	-
t-value	(-3.531)	(-2.054)	(-3.061)	(-2.917)	(-5.278)	-
θ_1^-	-0.079	-0.283***	-0.11	0.194	-0.217***	-
t-value	(-0.764)	(-2.758)	(-0.687)	-0.988	(-3.155)	-
H_0: $\theta_1=\theta_2=0$ (Φ)	6.239*	5.449*	4.688	6.256*	18.906***	-
H_0: $\theta_1=\theta_2$ (F)	1.755	2.772*	0.89	6.081**	9.489***	-
τ	-0.063	-0.113	-0.124	-0.127	0.107	-
LB(12)	0.73	0.612	0.287	0.425	0.694	-
AIC	-172.286	-182.155	-159.838	-92.406	-134.753	-

* Significant at 10%; **Significant at 5%; ***Significant at 1%. [a] Regression equation: $\ln P_{Dushanbe,t} = a + b * \ln P_{Rouen,t} + \varepsilon_t$, and,
$\Delta\bar{\varepsilon}_t = \theta_1^+ I_1 \bar{\varepsilon}_{t-1} + \theta_2^- (1 - I_1)\bar{\varepsilon}_{t-1} + \sum_{i=1}^{k} \nu_i \Delta\bar{\varepsilon}_{t-i} + u_{it}$

[ǂ] Number of lags selected according to the BIC, AIC and Ljung-Box Q (LB) statistic. [¥] The LB statistic shows first p number of the residual autocorrelations are jointly equal to 0. The Φ test is the threshold cointegration test with critical values from Enders and Siklos (2001). F is a standard F-test on the asymmetry of the price transmission. Numbers in brackets are t-values.

Table 7. Error correction model estimates.

Item (1)	Rouen (2)	Saryagash (3)	Dushanbe (4)	Gharm (5)	Khujand (6)	KurganTyube (7)
	Independent variables					
Dependent variable: first difference of the natural logarithm Dushanbe wheat price						
no. of lags	1;1	1;1	-	2;2	1;1	1;1
Symmetric error correction model						
δ_1	-0.218***	-0.147***	-	-0.144**	-0.200***	-0.252***
t-value	(-5.135)	(-3.857)	-	(-2.397)	(-3.828)	(-4.135)
AIC	-265.1791	-255.0712	-	-239.6453	-257.3066	-257.8824
Asymmetric error correction model						
δ_1^+	-0.177***	-0.074*	-	-0.13	-0.22	-0.216***
t-value	(-3.629)	(-1.787)	-	(-1.228)	(-1.621)	(-2.951)
δ_1^-	-0.268***	-0.357***	-	-0.135*	-0.194***	-0.194
t-value	(-3.11)	(-4.14)	-	(-1.905)	(-3.221)	(-1.646)
H_{01}: $\delta_1^+ = \delta_1^-$	0.89	9.132***	-	0.001	0.031	0.027
H_{02}: $\sum_{i=1}^{p} f_i^+ = \sum_{j=1}^{p} f_j^-$	1.89	2.549	-	7.51***	3.858*	5.753**
H_{03}: $\sum_{i=1}^{p} g_i^+ = \sum_{j=1}^{p} g_j^-$	3.135*	0.877	-	0.162	0.933	0.122
LB(4 lags)	0.462	0.767	-	0.989	0.557	0.521
LB(8 lags)	0.372	0.469	-	0.655	0.127	0.23
AIC	-264.842	-263.033	-	-242.262	-255.643	-256.132
Dependent variable: first difference of the natural logarithm Gharm wheat price						
no. of lags	5;5	1;1	2;2	-	3;3	5;5
Symmetric error correction model						
δ_1	-0.202***	-0.153***	-0.282***	-	-0.315***	-0.183**
t-value	(-3.432)	(-3.343)	(-3.413)	-	(-4.139)	(-1.994)
AIC	-63.2496	-54.75018	-66.8767	-	-71.8446	-63.02241
Asymmetric error correction model						
δ_1^+	-0.069	0.011	-0.198**	-	-0.027	0.001
t-value	(-0.974)	(0.184)	(-2.149)	-	(-0.246)	(0.003)
δ_1^-	-0.656***	-0.172*	-0.605***	-	-0.349***	-0.369**
t-value	(-5.09)	(-1.689)	(-3.555)	-	(-2.803)	(-2.187)
H_{01}: $\delta_1^+ = \delta_1^-$	19.883***	2.438	10.416***	-	5.174**	3.949**
H_{02}: $\sum_{i=1}^{p} f_i^+ = \sum_{j=1}^{p} f_j^-$	5.256**	6.65**	0.172	-	1.437	0.034
H_{03}: $\sum_{i=1}^{p} g_i^+ = \sum_{j=1}^{p} g_j^-$	0.013	0.11	4.233**	-	6.146**	0.323
LB(4 lags)	0.736	0.98	0.772	-	0.929	0.966
LB(8 lags)	0.378	0.097	0.419	-	0.183	0.973
AIC	-90.546	-63.631	-87.735	-	-94.924	-75.71

Table 7. Error correction model estimates (cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable: first difference of the natural logarithm Khujand wheat price						
no. of lags	2;2	2;2	1;1	1;1	-	2;2
Symmetric error correction model						
δ_1	-0.200***	-0.126***	-0.225***	-0.222***	-	-0.162**
t-value	(-3.609)	(-2.706)	(-3.184)	(-3.877)	-	(-2.378)
AIC	-104.145	-98.2807	-86.4300	-103.4415	-	-95.9164
Asymmetric error correction model						
δ_1^+	-0.062	0.034	0.057	0.204	-	-0.068
t-value	(-0.94)	(0.486)	(0.741)	(1.408)	-	(-0.953)
δ_1^-	-0.529***	-0.217**	-0.869***	-0.1	-	-0.4**
t-value	(-4.629)	(-2.367)	(-5.108)	(-1.434)	-	(-2.384)
H_{01}: $\delta_1^+ = \delta_1^-$	12.906***	4.035**	24.582***	4.112**	-	3.496*
H_{02}: $\sum_{i=1}^{p} f_i^+ = \sum_{j=1}^{p} f_j^-$	0.016	2.763*	0.856	18.239***	-	3.31*
H_{03}: $\sum_{i=1}^{p} g_i^+ = \sum_{j=1}^{p} g_j^-$	2.728	0.498	2.332	11.09***	-	0.294
LB(4 lags)	0.535	0.638	0.361	0.278	-	0.143
LB(8 lags)	0.374	0.244	0.209	0.283	-	0.155
AIC	-116.407	-99.846	-114.935	-118.117	-	-100.67
Dependent variable: first difference of the natural logarithm KurganTyube wheat price						
no. of lags	3;3	3;3	2;2	2;2	2;2	-
Symmetric error correction model						
δ_1	-0.138***	-0.05	-0.105	-0.129**	-0.106*	-
t-value	(-2.817)	(-1.313)	(-1.551)	(-2.291)	(-1.966)	-
AIC	-225.3968	-225.9969	-204.4587	-207.5223	-203.4381	-
Asymmetric error correction model						
δ_1^+	-0.169***	-0.034	-0.192**	-0.144**	-0.242*	-
t-value	(-3.184)	(-0.443)	(-2.468)	(-2.335)	(-1.69)	-
δ_1^-	-0.041	-0.066	0.048	-0.158	-0.097*	-
t-value	(-0.453)	(-1.231)	(0.332)	(-1.174)	(-1.773)	-
H_{01}: $\delta_1^+ = \delta_1^-$	1.715	0.1	2.462	0.01	0.933	-
H_{02}: $\sum_{i=1}^{p} f_i^+ = \sum_{j=1}^{p} f_j^-$	0.1	0.204	2.712	1.814	1.813	-
H_{03}: $\sum_{i=1}^{p} g_i^+ = \sum_{j=1}^{p} g_j^-$	0.074	0.119	0.279	0.001	6.028**	-
LB(4 lags)	0.96	0.907	0.26	0.253	0.206	-
LB(8 lags)	0.657	0.638	0.101	0.128	0.038	-
AIC	-223.981	-221.301	-208.548	-210.462	-210.496	-

* Significant at 10%; **Significant at 5%; ***Significant at 1%. Number of lags selected according to the BIC, AIC and Ljung-Box Q (LB) statistic. [¥] The LB statistic shows first p number of the residual autocorrelations are jointly equal to 0. [a] Regression equation takes the form of equation (8). H_{01} estimates asymmetric speed of adjustment, whereas H_{02} and H_{03} estimate the cumulative asymmetric effects of coefficients.

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