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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

The extent of market integration and transmission of food price shocks is a major determinant of price stability and overall food security, particularly in developing countries. Few studies have examined these issues for countries in Central Asia, however. This paper aims to fill this gap by examining 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 and asymmetric price relationships, a.k.a. rockets and feathers, we demonstrate how prices change in peripheral food-shortage markets compared to markets located in zones with abundant local production.

Our estimations show that local Tajik wheat market prices are indeed cointegrated with international and regional markets as well as across domestic markets. However, domestic market prices adjust more quickly to price increases in wheat markets outside Tajikistan than to price increases in other domestic markets. Evidence of substantial and significant positive asymmetry in peripheral markets such as Gharm 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. The 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.

Keywords: food security, market integration, price transmission, Central Asia, Tajikistan

JEL codes: Q11, Q18

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1. INTRODUCTION

Studies focusing on the role of markets, particularly the integration of markets, and the transmission of food prices between food-abundant and food-deficit locations have received a great deal of attention since the so-called food crises of 2007–2008 and 2010–2011. These crises spurred investigators to conduct empirical research to analyze the price relationships of major food products more thoroughly and to study the implications for food security and livelihoods in food-insecure countries.

These studies covered a wide range of trade and development policy issues, such as trade restrictions, alternative energy resources and biofuels, and other issues, which had differing effects on food markets and price transmission (see, for example, Serra and Zilberman 2013; Götz, Glauben, and Brümmer 2013). The studies also captured different aspects of horizontal price transmission (that is, between markets in different locations) or vertical price transmission (along a value chain of a food product) (see, for example, Esposti and Listorti 2013; Frey and Manera 2007; Hassouneh et al. 2012; Brümmer et al. 2009).

While the studies covered many geographic areas and focused on regions like northern and sub-Saharan Africa, South America, the Middle East, Eastern Europe, and Southeast Asia, very few focused on Central Asia as a region, or on a specific country in that region, as a case study. The only three research works exploring food markets in Central Asia from a price transmission perspective, to the authors' knowledge, are those by Brosig and Yahshilikov (2005), which focuses on wheat market integration and price transmission in Kazakhstan, and Akramov and Shreedhar (2012) and Abassian (2005), which study only long-term wheat price transmission in Tajikistan without exploring short-term 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 address two research questions. First, 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, aka rockets and feathers, between different markets. For this purpose we adopt the asymmetric error correction model using the threshold autoregressive (TAR) / momentum threshold autoregressive (M-TAR) model specifications proposed by Enders and Siklos (2001).

The contribution of this paper is twofold. First, literature studying food markets in Central Asia is limited, and this paper will contribute to the understanding of wheat markets in Central Asia, particularly from a market integration and price transmission perspective. Second, we hope the Tajikistan case study, based on its different socioeconomic, geographic, 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 on the reasons for or determinants of the rockets and feathers pattern, it does hope to stimulate further discussion on the importance of price relationships in spatially different markets and the policy implications for food security in various locations.

The rest of the paper is organized as follows. In the next section, we provide an overview of food security in Tajikistan and briefly discuss the importance of the wheat trade and the role of Kazakh wheat exports in the region that includes Tajikistan. The third section describes the theoretical framework and empirical method used in the analysis. The fourth section addresses the data and methodology, and the fifth section describes the empirical results. The final section provides some topics for discussion and conclusions.

2. OVERVIEW OF FOOD SECURITY CONDITIONS AND WHEAT MARKETS IN TAJIKISTAN

Food Security Conditions

Tajikistan is a small, landlocked, low-income, and food-deficit country. With about 8.2 million people and an area of around 143,000 square kilometers, Tajikistan is ranked 98th in the world in terms of both territory and population, according to the latest World Bank (2015) estimates. The country is mountainous, with limited arable land—only 7 percent of the total land is suitable for farming. Approximately 74 percent of the population resides in the countryside, and about 55 percent of the labor force is employed in the agricultural sector. With a total gross domestic product (GDP) of about US$5.64 billion in 2010 and US$820 per capita (US$2,147 per capita, adjusted for purchasing power parity), the country is one of the least developed transitional economies (TAJSTAT 2013; World Bank 2011).

Like the other Central Asian countries, Tajikistan suffered negative economic growth during the early post-independence period. However, unlike in any other Central Asian country, the economic collapse in Tajikistan was heightened by a civil war, which lasted five years, from 1992 to 1997. The civil war took more than 50,000 lives and displaced millions of people. The conflict directly affected 40 percent of the population, most severely in the eastern parts of Tajikistan, in the Gharm and Pamir area (UN 2004; DeRouen and Heo 2007). In addition to destroying livelihoods and damaging infrastructure, the conflict also prompted large numbers of professionals and skilled laborers to immigrate to neighboring and other post-Soviet countries.

The economy achieved its first post-independence positive GDP growth in 1997, followed by a remarkable average growth rate of about 7.2 percent from 1997 to 2012 (ADBI 2014). Economic growth surged especially during the period 2000–2008, when growth reached an average rate of more than 8 percent, only to be hindered by the global financial and food crises. Two major avenues for poverty alleviation in the country, according to the World Bank (2013), have been increases in wages and remittances, with their poverty-reduction contributions believed to be 50 percent and 30 percent, respectively. Nonetheless, with about 47.2 percent of the population living below the poverty line, Tajikistan is still among the least developed nations in transition (Akramov and Shreedhar 2012; World Bank 2013).

Tajikistan is a net food-importing country. In fact, it is heavily reliant on food and energy imports. Imports account for more than 50 percent and 90 percent of domestic food and energy consumption, respectively (FAO 2015; IEA 2014). More than 50 percent of cereals, 30 percent of beef, 80 percent of poultry products, three-quarters of vegetable oils, and most sugar consumed in Tajikistan is imported. Therefore, spikes in global prices during the 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 on food imports. At the micro level, high food prices pushed poor households to tighten their budgets and reduce diet quality, relying more on single staple foods such as wheat products.

Tajikistan's national food security strategy is reflected in various state regulations and programs adopted during the recent food crises: the "Agrarian Policy Concept, Food Security and Agriculture Investment Plan" within the National Development Strategy for 2006–2015; the Poverty Reduction Strategy for 2010–2012; the National Food Security Strategy of 2008; and the Law on Food Security in 2010. The 2009 Governmental Decree on the Food Security Programme until 2015 supports the national strategy. The government has also 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).

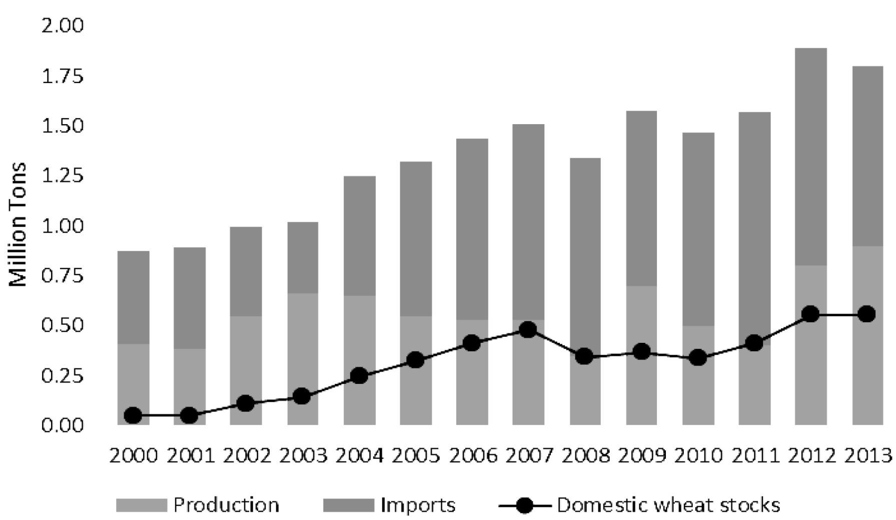
Reflecting on previous studies, Akramov (2011, 2012) suggests that structural changes in land and agriculture in Tajikistan have had a positive impact on food security in the country in several ways. First, land and farm restructuring enabled improvements in productivity, with smaller private farms being significantly more productive than larger collective farms. Second, allowing resource allocation based on market conditions and transitioning crop patterns more toward food crops increased domestic food availability. Food and Agriculture Organization of the United Nations (FAO 2015) estimates indicate that Tajikistan reduced the area under fiber crops (mainly cotton) from 0.285 million hectares in 1992 to about 0.200 million hectares in 2011, a decrease of about 30 percent. During the same period, the area under wheat increased from 0.183 million hectares to 0.311 million hectares and the area under cereals from 0.273 million to 0.410 million hectares, increases of almost 59 percent and 66 percent, respectively. Two major crops—cotton and wheat—dominate the Tajik agricultural system.

Sectoral reforms, liberalization of the economy and the labor market, and political stability improved food availability, increased household incomes, and supported strong economic growth. Increased incomes accompanied by an increasing inflow of remittances have not only had a positive impact on food security in general but also played a significant role in changing preferences for foods and slightly increasing food prices. 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.

Wheat Supply Markets and Trade

Wheat is the single most important staple commodity in the country. It provided about 52 percent of per capita daily calorie intake and constituted more than 57 percent of protein intake and 23 percent of fat intake per day in 2009 (FAO 2015). This makes wheat availability the single most important factor in food availability in Tajikistan. Overall, wheat availability in Tajikistan increased by more than 2.5 times over the period from 2000 to 2013, as shown in Figure 2.1. Domestic production increased from about 0.41 million metric tons1 in 2000 to more than 0.90 million in 2013. However, because of its poorer quality, particularly for bread making, the share of domestic wheat used for human consumption decreased from around 0.35 million tons to about 0.12 million tons, whereas its use for feed increased from just 12,500 tons to more than 620,000 tons during the same period, according to FAO figures. Local production of wheat has been volatile and heavily dependent on weather conditions and droughts in the 2000/2001, 2007/2008, and 2010/2011 seasons.

Figure 2.1 Wheat commodity balance of Tajikistan



Source: USDA (2014).

[1] All tons are metric tons.

Shifts in preferences and the use of domestic wheat led to increased imports of wheat and wheat products—an increase of almost the same magnitude, from 0.47 million tons in 2000 to 0.90 million tons in 2013. Import volume has increased steadily since 2004, mainly due to the increased volume of imported wheat flour until 2010, and the resurgence of wheat imports due to government taxation policies, such as a reduction in the value-added tax (VAT) for imported wheat, from 18 to 10 percent in 2010, to support the domestic milling industry (Randall 2015). Moreover, domestic wheat stocks have also increased more than 10 times, from 0.05 to 0.55 million tons during the same period.

ADBI (2014) describes Tajikistan as the most trade-open economy in Central Asia, as measured by the ratio between exports and imports of goods and GDP. Tajikistan was the second country in Central Asia accepted to the World Trade Organization (WTO), in 2013, after Kyrgyzstan, in 1998. Nonetheless, ratios of trade to GDP and accession to the WTO do not reflect other aspects of trade openness, and trade is seriously impeded by an unfavorable geographic location, lack of transportation links, and cross-border trade regulations, such as checkpoint and customs procedures, which all hinder the transportation of goods from one point to another domestically as well as internationally.

Trade in Tajikistan is based on land transport, as in most of Central Asia. Railroad and road connections in the landlocked country are also limited by mountain ranges. With regard to the wheat trade, Kazakhstan is the main and only net exporting country in the region. Its closer position than other regional competitors such as Russia and Ukraine makes it the dominant exporter in the region. Table 2.1 shows that Kazakhstan fulfills more than 90 percent of the wheat import requirements of Central Asian countries, including Tajikistan. The Central Asian wheat market is the largest single export market for Kazakh producers, accounting for about 44 percent of total Kazakh export volume in 2011.

Table 2.1 Wheat imports of Central Asian countries in 2011

	Kazakhstan		Russia		World	
Country/Region	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: Authors' calculations using trade data from Global Trade Information Services database (2013).

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

Beyond domestic production and imports, Tajikistan has been one of the largest recipients of donor food in Central Asia. FAO statistics suggest that delivery of wheat and wheat products in the form of food aid remained high during the first decade post-independence (that is, from 1992 until 2002), constituting about 8.56 percent of the domestic wheat and wheat product supply. The evidence shows that the international community has been responsive during times of major turbulence and environmental disasters, such as during the civil war between 1992 and 1997 and the major weather anomalies in 2001–2002 and 2005–2006, and has provided food aid mainly in the form of grain. The largest amount of aid supply was recorded in 2001, at about 158,000 tons, constituting 16.62 percent of domestic wheat supply, or more than two-fifths of domestic production. However, food donations have been in decline amid increased domestic production and strong economic growth. Subsequently, wheat and wheat product donations declined to 3.14 percent of domestic supply during the period from 2003 to 2011. Similarly, the international response during the food price shock of 2007–2008 was comparatively moderate, and donations of wheat and wheat products constituted only about 1.30 percent of domestic supply, or one-thirtieth of domestic production.

3. THEORETICAL FRAMEWORK AND EMPIRICAL METHOD

In general, the key theoretical concept in spatial price transmission analysis is spatial arbitrage, which implies that if markets are working well, the prices of homogeneous goods in different marketplaces will differ by no more than the costs of transport. Therefore, most empirical works in spatial price transmission analysis aim to assess whether the law of one price (LOP) holds true or not (Listorti and Esposti 2012). Fackler and Goodwin (2001) provide a very useful description of the conceptual framework and definitions of spatial price transmission, which we adopt in this analysis. It may be worthwhile to note that we assume "weak" LOP as 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 the wheat price at a destination market or domestic price, p_t^E represents the wheat price at a market of origin or export price, and c_{ij} is a transaction cost of shipping a good between markets. Moreover, we assume a 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 to drift apart, and therefore they move together.

For the analysis, we use the price relationship cointegration techniques proposed by Engle and Granger (1987) and the Johansen maximum likelihood (ML) test (Johansen 1988). Both methods assume linear and symmetric relationships between variables. Standard Johansen methodology starts with a vector autoregressive model and then reformulates it into a vector error correction model (VECM) as follows:

$$X_t = \pi_1 X_{t-1} + \cdots + \pi_k X_{t-k} + \zeta_t. \tag{1a}$$

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

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

In the Engle and Granger (1987) two-step specification, the long-term price transmission is given by the slope parameter β_1 in the equation

$$p_t^D = \beta_0 + \beta_1 p_t^E + \varepsilon_{t.} \tag{2}$$

Here, p_t^D and p_t^E are wheat prices in two different markets that are integrated of order one, $I(1)$; β_i is the degree of long-term price transmission (cointegration); and ε_t is an error term that might be serially correlated.

In the second step, residuals from equation 2 are obtained and θ is estimated. The null hypothesis of no cointegration (or, $\theta = 0$) is tested in the following regression:

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

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

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

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

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

The following equation represents the TAR model:

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

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

$$I_t = \begin{cases} 1 \; if \; \bar{\varepsilon}_{t-1} \geq \tau \\ 0 \; if \; \bar{\varepsilon}_{t-1} < \tau \end{cases}, \tag{6}$$

where τ is a threshold value. Logically, one can assume that the natural attractor for an equilibrium between two prices would be zero. However, there could be many reasons for the true threshold not to coincide with the natural attractor. One obvious reason would be transaction costs. Therefore, the true threshold value is obtained using a method proposed by Chan (1993). Chan 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) suggest that if the $\bar{\varepsilon}_t$ series exhibits more "momentum" in one direction than the other, for instance, the equilibrium condition is a more powerful attractor for negative values than for positive values, then the 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), the M-TAR modification of the Engle-Granger test (1987) has shown better power and size properties when asymmetric relationships between pairs of prices do indeed prevail.

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

4. DATA AND METHODOLOGY

In this paper, we use wheat market prices from six different locations or markets. Wheat prices from the French port of Rouen represent international wheat prices. Rouen is the closest major grain market to the Black Sea market, which includes Russia, Ukraine, and Kazakhstan. Saryagash is a Kazakh town on the border with Uzbekistan from where most wheat is transported to Tajikistan via the railroad crossing, as shown in Figure 4.1. The other four markets represent domestic Tajik markets. Dushanbe is the capital city and main food market; it supplies the urban population and is the primary market for imported products and for distribution to the eastern and southern territories of the country. Kurgan-Tyube is the administrative center of the Khatlon region, a *bread basket* in the south of the country comprising more than 60 percent of the total wheat area in Tajikistan. 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. Although most wheat is produced in the southern region of Khatlon, the majority of medium-sized and large flour mills are located in the Sughd region. Most wheat imported from Kazakhstan enters Tajikistan through Khujand and is processed into flour in the local mills. Gharm is a rather small and isolated market with about 8,000 inhabitants; it supplies the chronically food-insecure Rasht Valley in the east.

Figure 4.1 Major wheat trade route from Kazakhstan to Tajikistan case study sites

Source: Authors' illustration using a map from Geology.com.

In the empirical analysis, we use monthly data from January 2002 to December 2013 obtained from the 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 marketplaces (*bazaars*) in certain cities and towns, represent spot market consumer prices. The international wheat price in Rouen is obtained from the Home-Grown Cereals Authority website. Saryagash prices are obtained from Kazakh-Zerno Information Agency, one of leading agricultural market information centers in Kazakhstan.

As mentioned above, almost the entire international wheat trade in Tajikistan involves wheat imports from Kazakhstan. Transport of a good from Kazakhstan to Tajikistan via railroad takes less than a week, in general, unless there are border closures, which happens from time to time for various reasons that are unpredictable for traders. In addition, mobile phones and advanced communication technology enable a rapid and more frequent flow of market price information. For this reason, higher-frequency price data such as weekly data would be more suitable for our price transmission analysis. However, as Hassouneh et al. (2012) note, the availability of 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-frequency data rather than leaving the question unexplored.

We use monthly average exchange rates obtained from the National Bank of Tajikistan (2014) to convert prices into a single currency, the Tajik somoni, and use natural logarithms of real prices. To estimate price transmission coefficients, certain properties of individual price series should be tested and assured before preforming cointegration analysis. In particular, 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) test (Dickey and Fuller 1979) and the 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 has a strong null hypothesis that a time series is stationary and is therefore well suited for a robustness check.

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

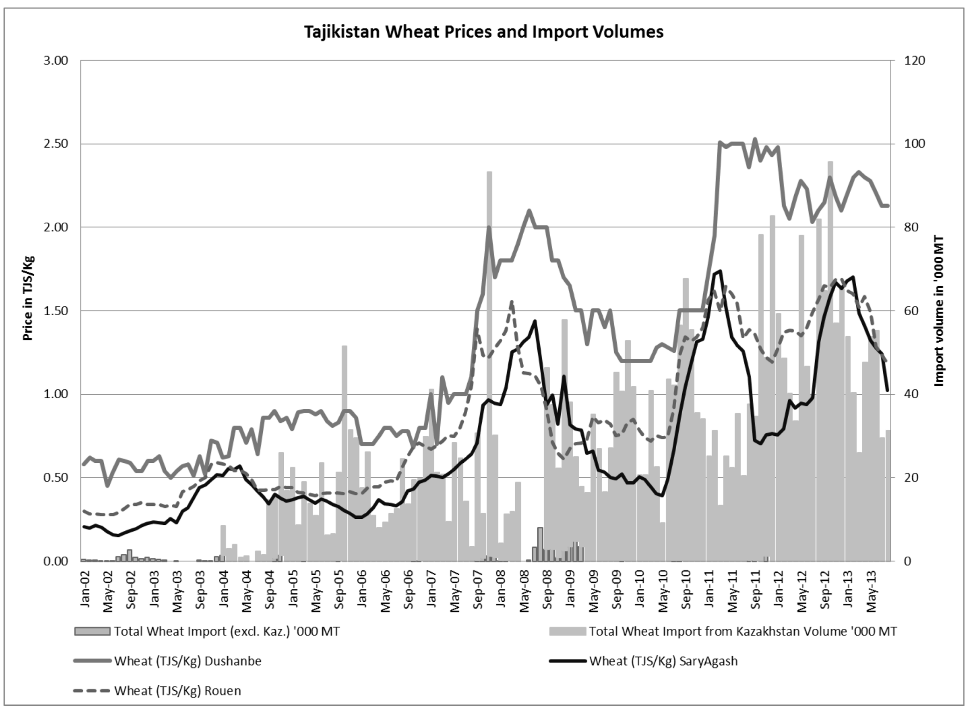
In the pre–final estimation stage, we use threshold autoregressive (TAR) and momentum threshold autoregressive (M-TAR) models to test asymmetric adjustment as in equation 5, with specification of (6) and (7), respectively. In almost all cases, the Akaike information criterion (AIC) and Bayesian information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

Throughout the model estimations, we consult BIC and AIC in order to choose the best-fit model specification with the appropriate number of lags selected and Ljung-Box (LB) statistics to ensure 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 5.1 and 5.2 show monthly wheat prices, presented in lines, and Tajikistan's wheat import volumes, presented in bars, over the 12-year period from 2002 to 2013. For ease of visualization, we separated the figure into two. Figure 5.1 shows that Dushanbe wheat prices are a bit more volatile than both Rouen and Saryagash prices. At the same time, Dushanbe prices seem to follow both prices well and adjust quickly, especially during price jumps. The same cannot be said, however, when the opposite occurs, and the Dushanbe price "hangs" longer after other regional and international prices fall. This is particularly evident in the relationship between Dushanbe and Saryagash prices and especially during the second wave of international food crises, in 2010–2011. Though smaller in scale, "hanging" of prices after the 2004 and 2007–2008 price spikes is also visible. Figure 5.1 also shows that the volume of imports has tended to increase since 2004, the earliest monthly trade data available for Kazakhstan wheat exports from the Global Trade Information Services (GTIS) database. Moreover, the volume of wheat imports tends to be higher in late autumn and early winter in Tajikistan, when local traders stock up before winter makes it literally impossible to transport goods in some peripheral locations because of bad road infrastructure in the country. As mentioned above and reiterated by many country-level studies, road infrastructure, particularly connecting major cities with peripheral towns and community locations, is very poor. Even one of the nationally most important road links, if not the most important link, between Dushanbe and Khujand is often closed during heavy snows in the winter. The same is true of Gharm and other locations in eastern Tajikistan, where some markets might be isolated for weeks.

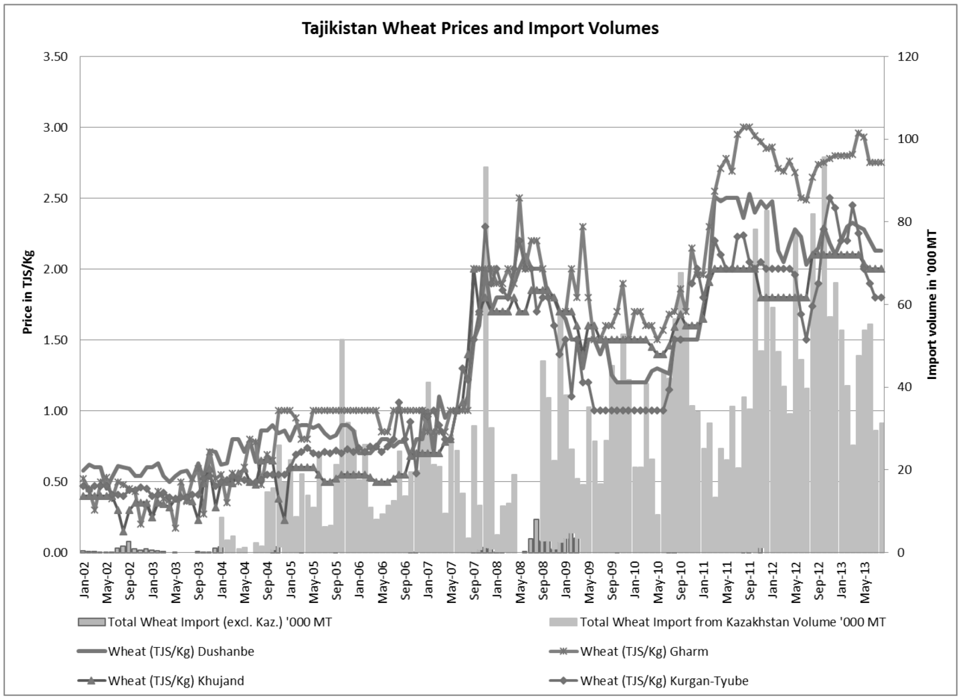
Figure 5.1 International (Rouen), regional (Saryagash), and local (Dushanbe) wheat prices



Source: Authors' compilation using Global Trade Information Services (2013) and World Food Programme databases (2014).

Figure 5.2 shows four different market prices in Tajikistan. Dushanbe wheat prices are in the middle of the pack most of the time, while Gharm prices are on top and Kurgan-Tyube prices at the bottom. The lines also show that the gap between prices has increased over the period under study. It is difficult to separate the lines from each other until 2004, but the gap is more visible after 2005 and increases particularly after the 2007–2008 and 2010–2011 price shocks. Similarly, local prices as a group tend to react to price changes more or less instantaneously before the 2007–2008 food crisis, whereas their adjustments tend to be differentiated after the price peaks. Again, Gharm prices hang above the rest of the group. Finally, it seems all prices demonstrate fairly nonstationary behavior.

Figure 5.2 Tajikistan wheat prices and import volumes



Source: Authors' compilation using Global Trade Information Services (2013) and World Food Programme databases (2014).

Formal stationarity test results are presented in Table 5.1. The ADF test 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, $I(1)$.

Table 5.1 Stationarity test results for wheat prices in markets of interest

	Price series					
Variable	**Dushanbe**	**Gharm**	**Khujand**	**Kurgan-Tyube**	**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 lag*	*1 lag*	*2 lags*	*1 lag*	*2 lags*	*1 lag*
ADF	-8.880***	-12.056***	-9.146***	-7.981***	-5.275***	-7.010***
KPSS	.0508	.0297	.0442	.0949	.0784	.0752

Source: Authors.

Notes: Tests were performed with a constant term and no trend. Number of lags was selected according to Schwarz's Bayesian information criterion (BIC). ADF = augmented Dickey-Fuller test; KPSS = Kwiatkowski-Phillips-Schmidt-Shin. * Significant at 10%; **significant at 5%; ***significant at 1%.

Concluding that all price series are $I(1)$ allows us to run cointegration analysis. The Johansen ML test estimations in Table 5.2 show that all but one (Gharm and Rouen) price series are cointegrated of order one, $I(1)$, at a 5 percent or lower significance level. The Gharm and Rouen price series are cointegrated at the 10 percent level. There are two potential reasons. On one hand, the more obvious reason is that Gharm is a small and rather isolated market, and price signals from international markets might have a weak reflection on local prices and take longer. On the other hand, Johansen ML tests assume symmetric relationships, whereas adjustments could be highly asymmetric.

Table 5.2 Johansen cointegration 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

Source: Authors.

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

Engle-Granger cointegration test results are provided in Table 5.3, as a robustness check. In all cases, the ADF tests reject nonstationarity and therefore reveal the existence of a cointegration relationship between individual price pairs. The 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 among each other. Long-term price transmission elasticity between different market prices, or the degree of cointegration, is shown in Table 5.4. The price transmission elasticity indicates the percentage change in the wheat price of local Tajik markets in response to a 1 percent change in another market. The numbers in bold between Gharm and Saryagash, Khujand and Saryagash, and Kurgan-Tyube and Rouen represent the degrees of cointegration, which are not significantly different from 1.0 (at 95 percent confidence level); therefore, perfect co-movement of prices in the long run cannot be rejected. Overall, in the long run a 1 percent change in an independent market price results in a 0.96 percent change in a dependent market price. This figure is on par with the average long-term price transmission coefficient prevailing within European wheat markets, 0.94 (Gillson and Fouad 2015), which is the highest in the world, demonstrating a very high level of cointegration between wheat markets.

Table 5.3 Engle-Granger cointegration 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

Source: Authors.

Notes: Critical values for the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) are -2.594, -1.950, and -1.613 at 1%, 5%, and 10%, respectively. [ł] Number of lags indicates an additional augmented lag change. Lag selection is based on the Akaike information criterion (AIC), Bayesian information criterion (BIC), and Ljung-Box Q (LB) statistic. [€] PP 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: $\ln P_{Dushanbe,t} = a + b*\ln P_{Rouen,t} + e_t$. * Significant at 10%; **significant at 5%; ***significant at 1%.

Table 5.4 Degree of cointegration 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

Source: Authors.

Notes: Standard errors are in parentheses. a Regression equation: ln PriceDushanbe,t= a+b *ln PriceCity,t+ et, where city denotes cities in the row. b Cointegrating coefficients in bold are not significantly different from 1.0 (at a 95% confidence level); therefore, a perfect degree of co-movement of prices cannot be rejected. *Significant at 10%; **significant at 5%; ***significant at 1%.

Nevertheless, unlike in European wheat markets, analyses of more dynamic relationships show nonlinearity. The M-TAR estimates in Table 5.5 show that indeed asymmetric adjustments in more dynamic price relationships are more prevalent than symmetric relationships. The Φ statistic allows us to reject the null hypothesis of no cointegration at a 5 percent or higher level in most cases except for Kurgan-Tyube, suggesting that most price pairs are cointegrated but with a threshold M-TAR adjustment. The AIC numbers from Tables 5.3 and 5.5 support the argument that cointegration with the M-TAR specification is a better fit in most instances except, again, for Kurgan-Tyube. The F-test for symmetric adjustment also follows the Φ statistic, indicating that the adjustment mechanism is asymmetric. Having more negative threshold (τ) estimates shows 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 a balance faster) than to price decreases.

Table 5.5 M-TAR model parameter estimates

	Independent variables[a]					
Item	**Rouen**	**Saryagash**	**Dushanbe**	**Gharm**	**Khujand**	**Kurgan-Tyube**
Dependent variable: Dushanbe wheat price						
No. of lags[l]	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

Table 5.5 Continued

Item	Rouen	Saryagash	Dushanbe	Gharm	Khujand	Kurgan-Tyube
	Independent variables[a]					
Dependent variable: Kurgan-Tyube 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	-

Source: Authors.

Notes: [a] Regression equation: $\ln P_{Dushanbe,t} = a + b*\ln P_{Rouen,t} + \varepsilon_t$, and, $\Delta\bar{\varepsilon}_t = \theta_1^+ I_1 \bar{\varepsilon}_{t-1} + \theta_2^-(1 - I_1)\bar{\varepsilon}_{t-1} + \sum_{i=1}^{k} \nu_i \Delta\bar{\varepsilon}_{t-i} + u_{it}$.
[ł]Number of lags selected according to the Bayesian information criterion (BIC), Akaike information criterion (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. * Significant at 10%; **significant at 5%; ***significant at 1%.

The positive finding of cointegration with the Engle-Granger ADF test and in most of the cases with the M-TAR adjustment justifies estimation of error correction in both forms of equations 4 and 8. The results of the error correction model estimates are presented in Table 5.6. Each respective Tajik market listed as a dependent variable in the table is regressed separately against different market prices in the columns. Three rows under the symmetric error correction model show parameter estimates for short-term price transmission elasticity or speed of adjustment (δ_1), their t-values, and the AIC for a model fit with the symmetric adjustment specification. Below that asymmetric error correction model parameters are estimated, 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; and Ljung-Box Q statistic and AIC. The Heaviside indicator in a model with M-TAR adjustment is set in accordance with equation 7. Parameters in the shaded area with the respective model specification are found to be a better fit according to the AIC.

The results show that Dushanbe wheat prices symmetrically adjust toward international wheat prices in Rouen, and prices in major local markets in Khujand and Kurgan-Tyube, with more or less the same speed of adjustment. About 20–25 percent of the discrepancy between market prices is adjusted in one month. However, adjustment of Dushanbe wheat prices seems to be asymmetric toward regional export prices in Saryagash, Kazakhstan. Adjustment toward a negative discrepancy (namely, to a price increase in Saryagash) from the price equilibrium is much faster, with about 35.7 percent of the discrepancy adjusted in one month. In contrast, adjustment toward price drops is only 7 percent in one month and significant at only the 10 percent significance level. Moreover, asymmetric error correction shows that Dushanbe wheat prices do not necessarily adjust to Gharm wheat prices, with no significance at the 5 percent level. This makes more economic sense than the parameter estimate (-0.14) obtained through the symmetric error correction model. As mentioned above, Gharm is a small market, and it is very unlikely and incorrect to expect Dushanbe prices to adjust to Gharm prices.

Table 5.6 Error correction model estimates

Item	Independent variables					
Item	Rouen	Saryagash	Dushanbe	Gharm	Khujand	Kurgan-Tyube
(1)	(2)	(3)	(4)	(5)	(6)	(7)
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
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

Table 5.6 Continued

Item (1)	Independent variables Rouen (2)	Saryagash (3)	Dushanbe (4)	Gharm (5)	Khujand (6)	Kurgan-Tyube (7)
Dependent variable: first difference of the natural logarithm Kurgan-Tyube 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	-

Source: Authors.

Notes: Number of lags selected according to the Bayesian information criterion (BIC), Akaike information criterion (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. * Significant at 10%; **significant at 5%; ***significant at 1%.

Unlike Dushanbe wheat prices, the AIC figures show that the Gharm wheat price adjustment mechanism toward other market prices is strongly asymmetric. Gharm prices adjust very quickly to price increases in other markets, with 35 to 60 percent of the discrepancy adjusted in a single month. At the same time, it seems there is very little or no significant adjustment toward price decreases in the short run, except toward Dushanbe prices. The significant adjustment of Gharm wheat prices toward both increases and decreases in Dushanbe prices is a reflection of Dushanbe's position as the closest major wheat market to Gharm, and it is most likely that price transmission between Gharm and other wheat market prices occurs through the prism of the Dushanbe wheat market conditions.

Similarly, Khujand wheat prices also show a strong asymmetric adjustment mechanism toward other wheat market prices. Khujand wheat prices adjust very quickly to price increases, with adjustment ranging from 22 percent in Saryagash in one month to almost 87 percent in Dushanbe. Like other major wheat markets in Tajikistan, Khujand wheat prices do not adjust to Gharm wheat prices.

In contrast to prices in other major wheat markets in Tajikistan, Kurgan-Tyube wheat prices demonstrate a very interesting pattern of price relationship toward other international and local wheat markets. The AIC numbers for symmetric and asymmetric error correction models are very close to each other, so arguments for asymmetric price adjustment mechanisms should be made cautiously. The AIC estimations are marginally higher for international markets, thus supporting the symmetric error correction model specification toward international markets, and marginally lower for domestic markets, thus supporting an asymmetric specification of the error correction model toward other domestic Tajik markets. In both model specifications, Kurgan-Tyube wheat prices seem not to adjust much toward regional wheat prices in Saryagash. However, negative signs in the speed-of-adjustment parameters support the argument for cointegration between Kurgan-Tyube and Saryagash prices. It is interesting that only Kurgan-Tyube wheat prices demonstrate faster adjustment toward price decreases in other markets. One plausible explanation for this phenomenon is that Kurgan-Tyube is in a bread basket region in the country, as mentioned above, and thus has a large enough market and local stocks to alleviate price increase shocks. Although the region lacks large storage facilities, local wheat production could be easily reserved in household conditions and could be used when imported Kazakh wheat products become too expensive. Therefore, Kurgan-Tyube adjusts to price decreases in other places but does not necessarily adjust to price increases, instead exploiting available local resources and stocks.

6. DISCUSSION AND CONCLUDING REMARKS

Our estimations show that local Tajik wheat market prices are indeed cointegrated with international and regional markets as well as across domestic markets. This market integration contributes to price stability and food security in Tajikistan's food-insecure economy. However, our results also show that domestic market prices adjust more quickly to price increases in other wheat markets than to price increases in domestic markets. Evidence of substantial and significant positive asymmetry in peripheral markets such as Gharm 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. The 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 the determinants of such asymmetric mechanisms is beyond the scope of this paper and would require a thorough 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 the Tajik government has taken major steps to improve food security in the country, as discussed in the second section of the paper, the national strategy on food security envisages achieving food security primarily through improving agricultural productivity and attaining self-sufficiency in major food commodities. Unfortunately, the role of domestically, regionally, and internationally integrated markets and trade does not receive enough emphasis within national policies. Moreover, as Ecker and Breisinger (2012) point out, availability of food, despite being the first and most important pillar of food and nutrition security, is only one of four pillars of extended food security; the other three are access, utilization, and stability. Therefore, it is advisable for the 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 only one side of the story, and a more comprehensive approach to food security should be considered. The existence of both relatively food-scarce and relatively food-abundant regions indicates that the government should take a more active role in supporting the interconnection of these regions and the flow of food and other resources by eliminating barriers and lowering transaction costs.

Transportation is often considered the main constituent of transaction costs. This is particularly true when the transportation infrastructure is underdeveloped. Bad road infrastructure in Tajikistan naturally results in higher costs for transport from central markets to peripheral markets and from agricultural areas to food-dependent areas. In turn, higher transaction costs accompanied by higher adjustment costs are likely to result in more salient asymmetric adjustment mechanisms between these two types of markets. The Tajik government has invested in improving transportation infrastructure through various regional programs and projects, such as the Central Asia Regional Economic Cooperation Program (CAREC), supported by multinational donor organizations (World Bank 2007). However, these projects and activities concern more centrally important road links, and addressing the problems in peripheral locations may require more time and may be delayed until the government prioritizes local infrastructure development in those areas. Therefore, in the shorter term, appropriate food assistance, income transfers, and targeted assistance programs in those areas could be relevant in addressing the asymmetric impact of regional disparities and food price shocks.

Additionally, although wheat is primarily grown in the south of Tajikistan, the majority of flour mills are located in the north of the country. Increasing the processing capacity for local wheat, preferably mixed with wheat imported from Kazakhstan to achieve better flour quality, would boost the development of the milling industry in the south as well as improve food availability in the country.

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